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NOAA AUTHORIZATION—SPACE

HEARING

BEFORE THE

NATIONAL OCEAN POLICY STUDY

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSION

ON

AUTHORIZATIONS FOR THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION'S ATMOSPHERIC AND SATELLITE PROGRAMS

MAY 19, 1987

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NOAA ATMOSPHERIC AND SATELLITE PROGRAMS AUTHORIZATION

TUESDAY, MAY 19, 1987

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
NATIONAL OCEAN POLICY STUDY,
Washington, DC.

The Committee met, pursuant to notice, at 10:09 a.m., in room SR-253, Russell Senate Office Building, the Hon. John F. Kerry (Vice Chairman of the Study) presiding.

Staff members assigned to this hearing: Jim Drewry, staff counsel and Pete Perkins, minority professional staff member.

OPENING STATEMENT BY SENATOR KERRY

Senator KERRY. The hearing will come to order.

We are delighted to welcome Dr. Calio and other witnesses here for the oversight hearing on NOAA's atmospheric, satellite and environmental programs. I am pleased that Dr. Calio has been able to join us. Obviously, from the National Weather Service to NESDIS to the oceanic and atmospheric research issues there are a host of concerns which we all have and we are facing, as we always seem to be facing, at least over these past years, some very tough choices between priorities.

And the ocean side seems to be suffering for choices being made on other priorities. We had some hearings on that a week or so ago, had a chance to explore some of those issues, but the budget concerns remain extreme, not to mention when measured against some of the larger global climatic issues which are of increasing concerns now—greenhouse, ozone and others.

So I am happy that we are going to have a chance to explore some of the process of the selection of those priorities, the choices that have been made, and some of the questions which loom large in the minds of many of us here on the Hill about where and how we might be better addressing some of those priorities.

I am pleased to be able to welcome Senator Nickles from Oklahoma, who has asked to lead off with some testimony, but before I turn it over to you, Senator, I would like to ask if my colleague has any opening remarks he would like to make. Senator Pressler.

OPENING STATEMENT BY SENATOR PRESSLER

Senator PRESSLER. Mr. Chairman, the purpose of today's hearing is to examine NOAA's satellite and atmospheric programs and policies in order to assist this Committee in developing authorizing legislation for the coming year. We will be exploring all aspects of NOAA's operations in these areas as the hearing progresses, but I would like to take some time at the outset to focus on one issue in particular because of what I perceive as a serious lack of policy direction from both the administration and Congress—namely the Landsat program and the recent attempt at commercialization.

HISTORY

Commercialization initiatives began in the late years of the Carter Administration and have continued with vigor throughout both terms of the present administration. The nominal issue has been one of commercial viability of the Landsat system. But in practical terms it has been a debate over the very existence of the program. In 1984 this Committee favorably reported the Landsat Commercialization Act, which was subsequently enacted into law. The 1984 Act was to establish U.S. policy in land satellite remote sensing and chart a course into the next decade for its implementation. Instead, our Landsat policy today is largely incoherent or even nonexistent.

Today's hearing, Mr. Chairman, and the legislation which will follow give us an opportunity to address this problem. I hope it is an opportunity which shall not be lost. Before turning to specific recommendations on how to put the policy back on track, it is necessary to take a closer look at exactly where we stand today.

The 1984 Act and subsequent legislation called for a two-satellite program. Since then we have seen a series of proposals and counter-proposals, some calling for one satellite, some for two, and some for scrapping the program altogether. All have had different price tags and different conditions. But we never have been able to reach a consensus. The net effect has been to jeopardize the entire program.

As we speak, OMB currently has under consideration the latest commercialization proposal and has tied to it the issue of continued operations funding for our existing Landsat satellites. In the meantime, the French, Japanese, and a host of other countries are swiftly gaining ground in an area which heretofore has been almost totally dominated by the U.S.

NEED FOR ACTION

As we continue to sputter about on the Landsat issue, the clock keeps running. The longer we delay the final decision, the greater the potential for seriously jeopardizing the program's future. Not only are other countries rapidly closing in on our technological leadership, but already we face a serious data gap which is growing wider with each passing delay.

Soon we will reach a point beyond which we cannot hope to recoup our losses. Time is running out. Action is needed now if we are to stay in the satellite land remote sensing game. Several steps need to be taken immediately if we want to stay in the business in which we already have invested $1.5 billion. Let me identify the steps needed to be taken and attempt to suggest a direction in which to proceed with each.

LANDSATS 4 AND 5 OPERATIONS

It should not be forgotten that we have two satellites in orbit today, and 15 years of data from these and earlier Landsat satellites. Landsats 4 and 5 continue to collect and transmit valuable data even though they have surpassed their nominal life expectancy of three years. But the administration budget provides no funding to operate these satellites or data facilities in fiscal year 1988. This must be corrected immediately.

Senator Riegle and I have contacted both OMB and the Department of Commerce on this issue. The response thus far has been that it is being considered in conjunction with the commercialization issue. I fail to see how the two issues are inextricably linked. Even if we were to scrap the future program altogether, it certainly would not make sense to allow two perfectly good satellites to go unused for lack of operating funds.

My concern over this issue was heightened by the fact that there as been at least one interpretation that the commercial operator would be expected to provide for the operation of these satellites beyond fiscal year 1987, a view which I find hard to reconcile with the 1984 Act and impossible to reconcile with the existing commercial contract. And it is one which is not shared by the vast majority of those familiar with the program.

It is my belief that we should act now to provide these operating funds in order to protect our huge existing investment in the current program. As I said before the House Committee when I testified there six weeks ago, it would look pretty silly for us to have two perfectly good satellites orbiting the earth unused because we failed to provide the operating funds.

FUTURE SATELLITES

Much of the controversy surrounding the future of commercialization centers around whether the initial proposal will include planning for on satellite or for two. Frankly, I would be happy with either alternative, as long as we can get something going. In the best of all worlds, we would proceed with Landsat 6 as fast as possible and substantially improve future satellites to follow.

The one satellite versus two satellites debate centers around the issue of commercial viability. It is time for us to recognize that the program is not commercially viable in the classic sense of selling an adequate amount of products to pay the bills. It never has been and will not be in the foreseeable future. Once this fact is recognized, the issue of one versus two satellites diminishes in importance, but it does not diminish the need for or justification of the program.

For too long the Landsat issue has been driven by the question of commercial viability. That has been a mistake. I argued that point in the early days of the commercialization proposal. I argued it in 1984. I continue to do so today. The difference now, however, is that this position seems to reflect the majority rather than the minority view. And that brings us to the heart of the issue.

The question should not be whether Landsat is commercially viable; it is not—at least not today. Rather, the question should be whether it is important enough as a national asset to justify ongoing and substantial Federal support for its continued existence. I believe that it is. Certainly the French, the Japanese and a host of others believe that their own programs are. In addition, there is a growing recognition within our own government as to the importance of Landsat as a national asset. Perhaps the clearest illustration of this point is the strong support from the Department of Defense and the intelligence community for the Landsat program, as manifested in testimony before the House Committee this past March.

In addition, there are countless examples of broader benefits to society which do not easily lend themselves to the kind of tangible budget implications preferred by some in their analyses of the program's justifications. For example, how can you calculate the value of thousands of acres of forests not burned because firefighting equipment was strategically located based on satellite observations? How do you calculate the value of lives not lost and property not destroyed because a dam did not burst because it was never built on a site that was determined to be unstable from satellite data studies?

How do you determine the value of lives not lost because a mine roof did not collapse because a study of satellite data indicated the need for installation of roof bolts or other protective devices? And how do you calculate the value of a more efficient and ecological use of Federal wildlife preserve lands? It cannot be done. And those limited in their observations by looking at budget numbers, commercial viability and economic return will never support a Landsat program.

Also, how do you justify in economic terms the importance of Landsat data to the study of global systems? Scientists by the score will testify to the importance of Landsat data in this regard. But an inquiry limited in its scope to the commercial or economic justifications of the program will never support is continuance.

So, in conclusion, Mr. Chairman, my point is that we need to take off the blinders of short-term economic justifications and commercialization in our assessment of the need for this program. Its future should not hinge on its commercial viability. It is not solely a commercial program. It is critical to our nation's scientific research, our intelligence community, and our role as an international leader in land remote sensing technology.

It is with these principles in mind that we should go forward in reestablishing our commitment to the Landsat program. It has been three years since the Commercialization Act, and we still have no program. We have got to move forward. And we should do so with the realization that this is not, and cannot be, a purely commercial program. It must involve a substantial and ongoing commitment by the Federal Government to ensure data continuity, steady technological advancement, and continued world leadership.

It is time to face the fact that if we expect the private sector to assume the full cost of the program, we are really saying that the program is dead. That would be a tragic mistake. We cannot afford to place ourselves in a position of being dependent upon foreign governments for providing us fundamental scientific, economic and intelligence information. We do need to establish international cooperative initiatives with other countries, but cannot be put in a position of total dependence upon them.

So I hope the administration will act soon and act favorably on the proposal now being considered. In so doing, I hope we can begin to put this program into perspective as a valuable national asset rather than viewing it in the narrow context of economic benefits and commercialization.

Thank you, Mr. Chairman.

Senator **Kerry**. Thank you very much, Senator Pressler.

I have a statement from Senator Hollings for the record.

[The statement follows:]

OPENING STATEMENT BY THE CHAIRMAN

This hearing is the third in a series held by the full Committee and the National Ocean Policy Study to examine and evaluate ongoing programs of the National Oceanic and Atmospheric Administration. Today, testimony will focus on the funding and activities of the National Weather Service, the National Environmental Satellite, Data, and Information Service and the Office of Oceanic and Atmospheric Research.

NOAA's atmospheric activities center in large part around the responsibility to provide routine and severe weather forecasting services and to monitor and predict climatic trends. Because weather events touch the lives of all Americans, these programs are critical. For this reason, I am pleased that the Administration has recommended adequate funding for them.

Weather statistics provide evidence that money authorized and appropriated for NOAA's weather-related activities is money well spent. In the area of severe storm warnings, the agency's effort to improve forecasting and increase public hazard awareness has saved hundreds of lives. For example, in the United States from 1970 until 1979, tornadoes annually killed an average of 100 people. By contrast, since 1980 that number has been reduced to under 30 people per year, although the incidence of tornadoes has remained about the same. This drop can be attributed to more accurate warnings provided further in advance of the event by the Weather Service, and to increased public awareness and confidence in those forecasts.

Similar dramatic reductions have been achieved for losses due to hurricanes. In the 1950s and 1960s, hurricanes claimed 60 to 70 American lives each year. That loss has now dropped to 33. Two years ago, in 1985, meteorologists recorded the largest number of hurricane strikes along our coasts in at least 20 years. Yet, despite over $4 billion in property damage, deaths were held to 28. Hurricane Elena alone forced evacuation of more than 1.7 million people from the coasts of the Eastern Gulf and destroyed billions of dollars of property, but no fatalities occurred.

While our goal must remain to prevent loss of even a single life, NOAA's efforts to protect human well-being and minimize weather-related losses should be recognized and commended. I am impressed by the agency's obvious commitment to improving those services through their modernization program. In addition, I am pleased to see increased attention focused on understanding and predicting climatic changes which occur over longer periods of years, decades, and even centuries. Such research already has shown great promise for predicting and adjusting to climatic changes triggered by El Nino ocean warming events. NOAA's contribution also will be vital to development of comprehensive policies which respond to such long-term problems as global warming and stratospheric ozone depletion. I look forward to today's testimony to examine and evaluate current programs and to point out new directions for the future.

Senator **Kerry**. Senator Nickles, we welcome you to this hearing and appreciate your desire to be heard on this issue, on related issues to it, and without further ado we look forward to hearing your comments.

STATEMENT OF HON. DON NICKLES, U.S. SENATOR FROM OKLAHOMA

Senator NICKLES. Thank you very much, Mr. Chairman. I appreciate the opportunity to testify before this Committee, both yourself and the leadership of Senator Pressler.

Senator Pressler, I would just comment I compliment you on the leadership that you have shown on Landsat and, if the Chairman would indulge, my comments are in support of a strong Landsat program. I personally think—and I have spent some time on this issue, and I remember full well the debates that we had and discussions that we had, going back for the last several years, going back to Mr. Stockman as former head of OMB and some of the debates that we had with various administration officials.

It is clear that the Nation's Landsat program is an important technological and strategic asset. It can provide information to help maximize crop yields and help locate promising oil and gas bearing geologic formations. The Oklahoma Conservation Commission has informed me that the Landsat data are "of great value in water quality assessment work", providing a desirable alternative to collecting samples from the hundreds of lakes in Oklahoma.

However, it is equally clear that the agriculture industry, the oil and gas industry, and the Western states are not in a position to provide significant funding to the Landsat program at this time. Moreover, the principal users of the Landsat data are the various federal agencies. I am, therefore, concerned about what appears to be an unjustified reluctance to contribute funds to the Landsat program on the part of the user federal agencies. I believe that the federal government should commit to NOAA sufficient funding for two satellite and one ground station Landsat programs.

Mr. Chairman, I hope that this committee will provide sufficient funding to purchase two satellites and a new ground station. A strong statement of federal commitment must be made so that private Landsat users have reason to commit to future business with Landsat.

The administration has been divided on the future of Landsat. There has been a lot of division, a lot of controversy. But I would just urge this Committee to go forward with a very strong Federal commitment for two new satellite programs and a new ground station as well.

I think Landsat is a very important national asset and it is one, as Senator Pressler indicated, that we should not allow ourselves to lose the outstanding leadership which we have had since the beginning of this program. I really think it would just make very little sense for the United States to be dependent or reliant on the French or the Japanese or other countries for the purchase and acquisition of this information. Maybe that information would be available, and maybe it would not be.

But this is truly a national asset. It is a national asset that is certainly important to a variety of Federal agencies which I think should be very forthcoming in their support for the program—the Department of Defense, the intelligence community, certainly the Agriculture Department, the Energy Department. There is a wealth of information that is vitally important to the strategic and national interests of this country and to the world as well, and it just would be, I think, a very serious mistake if we allowed the United States to lose our leadership.

As Senator Pressler has mentioned, we have invested well over $1 billion in the Landsat program to date, and it has reaped significant benefits to our country and, I think, again to the world. I would just hate to see us abdicate our leadership. I think we need those satellites. Satellites 4 and 5 are well on in their years. We need to be planning and funding their replacements, and that would be satellites 6 and 7. From the information that I have heard, satellite 7 can come on in the outyears, but I think we need to be funding. We need to be planning.

This Committee and others, the Appropriations Committee, need to be talking to the professionals to figure out how we can save money concerning launches. Certainly the Shuttle disaster has made that more expensive, and certainly an obstacle for us to overcome, but we should not lose sight of our objective, and our objective would be, in my opinion, to maintain the leadership which we have had in this vitally important program.

So again I compliment this Committee for looking into it, for your hearings today, and for the leadership which you have provided and will provide in this very, very vitally important issue. I think too many of our colleagues have kind of neglected or maybe not taken a close enough look at how important this it to our country.

You look at the Chernobyl accident. Those pictures that came from Landsat satellites I think really did provide a valuable asset to us in being able to see what was happening. Again, you talk about the planning, whether or not to build a dam in a particular area, what is happening in our forest areas, where possible deposits are in certain areas, what is happening in weather situations not only in our country and what is likely to happen but in other countries as well. The potential from Landsat is enormous. I think it has been a tremendous asset and again I would encourage this Committee to show forth a very strong Federal commitment.

I hope that commercialization will proceed and progress, but I do think it is important that we move forward with a Federal program and commitment for Landsat.

Senator KERRY. Senator, thank you. We appreciate your taking the time to come here and understand your interest in it. As the Senator knows, it is always important to begin the process of signaling a stronger and broader Congressional interest in any particular program such as this, and we appreciate your taking the time to do that today.

Senator NICKLES. Thank you, Mr. Chairman.

Senator KERRY. Did you have a comment or a question?

Senator PRESSLER. I want to thank Senator Nickles for his outstanding leadership in this area and for his fine statement. I would address one question to him which I am going to address to every witness, and that is do you feel there is a need for a continued government role in the Landsat program or should we allow it to live or die based on commercial viability?

Senator NICKLES. Well, Senator, as I alluded to in my statement, I think it is awfully important that the United States have a Landsat program. As you mentioned, the investment that we have is enormous. I really would hate to think that we would be buying this information from the French or the Japanese or another country. I think it is too important.

Again, we have had leadership; let's not abdicate. We have got a tremendous investment not only in dollars but in personnel and research and facilities. As you mentioned, we still have two viable satellites. Let's utilize those. Let's plan and fund the replacements and be prepared to maintain the leadership that we have had in this most important area.

Thank you both very much.

Senator KERRY. Thank you very much, Senator. We appreciate it.

We will now commence with the first panel of two panels that we will have today, and I would ask Dr. Calio, the Administrator of NOAA and his accompanying associates to take the table. Thank you.

STATEMENT OF HON. ANTHONY J. CALIO, ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE, ACCOMPANIED BY TOM PYKE, ASSISTANT ADMINISTRATOR FOR ENVIRONMENTAL SATELLITE DATA AND INFORMATION SERVICE; KATHLEEN CHARLES, DEPUTY COMPTROLLER; DR. JOSEPH FRIDAY, DEPUTY ASSISTANT ADMINISTRATOR FOR THE WEATHER SERVICES; AND DR. ALAN THOMAS, DEPUTY ASSISTANT ADMINISTRATOR FOR OCEANIC AND ATMOSPHERIC RESEARCH

Dr. CALIO. Mr. Chairman, my associates.

Tom Pyke, to my right, Assistant Administrator for Satellites; and to his right Kathleen Charles, Deputy Comptroller. And to her right, Joe Friday, Deputy Assistant Administrator for the National Weather Service and atmospheric programs. And to his right Dr. Alan Thomas, Deputy Assistant Administrator for our research and development operations for oceans and atmosphere.

Senator KERRY. Thank you very much. Let me just say to you that if you want, and you can choose either way, obviously, but we would accept your full statement for the record, and if you cared to summarize or felt comfortable doing so we would be happy to accept it in full.

Dr. CALIO. Thank you, Mr. Chairman.

Let me first hit a couple of high points and take just one or two minutes and then we can get into questions and answers. I am indeed delighted to be here with part of the management team for the atmospheres and satellites part of NOAA, and I hope we can provide some insights today in answering some of your questions.

We will continue in our 1988 budget request to you to make progress, as we see it, on the modernization of the National Weather Service. That is a very high priority for us and we have put a great deal of effort into that modernization program over the past six or seven years.

There is increased funding requested in that submission to begin an Automated Service Observations System for ourselves and for the FAA. We also have funding in there for contracting for the system development of an Interactive Communications and Data

Processing System for the Weather Service, called AWIPS, and continue the production of our Next Generation Radar systems, called NEXRAD.

So with the systems which we are putting in place, developing, we will modernize the National Weather Service with the latest science and technology available. An increase is being sought for a project to plan and demonstrate operational deployment of these three new technologies and techniques in modernizing the National Weather Service.

NOAA continues to acquire and deploy a demonstration network of Wind Profilers in the Central U.S. and we continue our research and development on a complementary system to measure temperature and water vapor. If these systems prove successful, it may be possible to replace the current costly upper air observation network maintained by the National Weather Service. And our efforts to improve our hurricane system for forecasting landfall and storm intensity are all supported in the fiscal year 1988 budget request.

Key research programs that will be maintained include understanding and predicting the effects of El Nino through the International Tropical Oceans and Global Atmospheric Program; increasing our understanding of global atmospheric chemistry, including the study of trace gases in the atmosphere and their contribution to the "greenhouse effect," as well as to ozone depletion; and the coordination of the National Acid Precipitation Assessment Program, a multi-agency research effort where NOAA provides a very strong role in atmospheric processes and supporting research activities.

In fiscal year 1988 NOAA seeks an increase of approximately $54 million for the polar-orbiting weather satellites. The major portion of this increase, $42 million, is to buy spacecraft, instruments and launches to maintain a two-polar spacecraft configuration that reduces the risk of a data gap and provides a backup satellite in orbit. The remaining portion of the proposed increase is for the ground system resulting from changes in the instruments and communication characteristics of the NOAA J, K, L and M spacecraft. NOAA's search and rescue capability will continue to be provided on these spacecraft.

The procurement and launch planning schedule for the polar orbiters assumes replacement launches every 15 to 16 months. Currently NOAA 9 and NOAA 10 are the operational satellites in orbit. The sounding capability of NOAA 9, which enables us to take atmospheric measurements in cloud-covered areas, has failed. The next satellite, NOAA H, has been called up for launch for late October of this year. The spacecraft under procurement include NOAA I and J, and a contract award for the K, L, M series will be made late this year or early next.

A decrease is proposed for NOAA's geostationary satellite system for fiscal year 1988. GOES 7 was successfully launched in February of 1987 and restored us to a two-satellite coverage again. The next series of newly-designed satellites, GOES I through M, will carry improved instrumentation for supporting National Weather Service forecast requirements. This series is under development and will provide service through the late 1990s. An increase is sought for upgrading the GOES ground equipment and facilities to match the higher performance of the GOES I through M series.

NOAA has issued a solicitation for procuring commercial launch service for GOES I through M. We expect to meet our mission requirements through commercial services consistent with the Department of Commerce and Administration policies to support and utilize the emerging commercial launch services industry.

The budget for Landsat commercialization includes an increase of approximately $35 million for the commercial Landsat system. In 1985 the contract was awarded, as has been stated, to EOSAT to build and operate a commercial land remote sensing satellite system and to sell its data. The 1988 request includes funding consistent with the plans submitted originally to Congress to build and launch a Landsat 6 spacecraft and instruments and to construct a support system on the ground.

As you know, the Senate did not approve the plan submitted by the administration and we are in the process of reviewing other commercialization plans.

In closing, I would like to call the Committee's attention to ongoing discussions in both the government and academic science communities on the need to take a systems approach to earth sciences. As part of the effort to understand global change, a new committee on earth sciences was created recently by the President's Science Advisor. I have been asked to chair the committee. The committee will coordinate the Federal research efforts on earth sciences, identify policy and international issues and provide committee recommendations to the Director of the White House Office of Science and Technology Policy. This committee will also make an annual report to Congress on the greenhouse effect and other indicators of global climate change. This cooperative scientific approach will be used as a source of advice for setting NOAA research goals and program priorities in the upcoming years.

That is a quick summary, Mr. Chairman of the highlights of our fiscal year 1988 request in satellites and atmospheres, and we are prepared to answer any questions you may have.

Senator KERRY. Thank you very much. I am going to place myself under a ten-minute time frame here because I am not sure who will yet come, and then we can always come back and revisit some issues, if need be.

There are a lot of questions obviously to ask. I would like to begin with one that has disturbed a number of people. Let me read perhaps from the Atlanta Constitution editorial, if I can, and touch on this ozone issue and NOAA's role therein.

A recent editorial said—and I will just skip through it, but the gist of it is that you might say that President Reagan's men, took the torch from the Carter team, which in 1978 banned the use of chlorofluorocarbons in aerosol propellants, and were themselves on the verge of leading recalcitrant Europeans toward wider, more meaningful prohibitions that would have drastically and speedily reduced the productions of CFCs worldwide:

> Suddenly the stout U.S. stand in United Nations-sponsored bargaining conducted in Vienna and Geneva over the last few months lost all its starch. The U.S. delegation wound up acquiescing in an agreement that would freeze CFCs production at

> 1986 levels, and then slowly reduce it in the 1990s, on a timetable that falls woefully short of original U.S. targets.
>
> The U.S. position, alas, was undermined from pressure from the CFCs industry group, and from second-level Reagan appointees, who adhere to ideas on safeguarding the planet's ecology that would have received a hospitable hearing from Attila the Hun.

There are a number of other articles that have detailed in great form some of the individuals who have played a role in that. I'm disturbed that one of those individuals is in NOAA, and I would like to ask you whether you would feel that NOAA's role at these talks was really to provide expertise and scientific background materials.

Would you say that's a fair assessment of what NOAA should be doing?

Dr. CALIO. Absolutely.

Senator KERRY. Why then was a lawyer appointed to the NOAA team who took part in those talks in a way that went beyond the norm of providing scientific and other kinds of data.

Dr. CALIO. Well, maybe it is the way in which policy is developed. Because I think in respect to very important considerations like chlorofluorocarbons and halons, that the science and the policy are interactive.

It is a social, economic, scientific assessment that has to take place. And in most cases, I interact with my scientific team in trying to provide a management overview of what they do, and interact with them so that we can bring the right scientific concepts forward and the data forward, and try to establish the appropriate policy.

In the particular case, we had the science adviser, who was the director of our aeronomy laboratory, and he is probably one of the best atmospheric chemists in the country, advising us as to what we thought—what he thought with respect to the data, and what scientists understood in the way of theories, and the way scientists understood, and the way an interpretation of that data, the furthest we could go in policy that could be supported by science.

And that is exactly how we worked within the agency. We do have a free association. And we debate the issues internally. And they include policy elements as well as scientific elements.

I do not know how you can separate the two, Mr. Chairman. I think they are very important. And I am an advocate of looking at the science when we establish the policy, and have somebody who can understand and interpret it.

Senator KERRY. Well, last week, you testified before the Senate Environment Committee and said the sooner we begin to make reductions, the less severe those reductions may have to be.

Dr. CALIO. That is correct, or pretty close to it.

Senator KERRY. In light of the scientific analysis, are you concerned about the drawn out schedule that has now been agreed upon?

Dr. CALIO. Let me hit that on two sides. Because I do not—and one of the concerns last week, and I sort of interpret it in yours, is that we have changed our strategy. I do not think so.

We are looking at what has to be done in the next ten years. And I thought we went into this international protocol with a notion of what rollbacks are necessary; and if necessary, up to 95 percent over the next ten years.

We have not changed that as an objective.

Senator **Kerry**. But that does not deal with the question of rapidity of reduction.

Dr. **Calio**. I am coming to that. We agree on the freeze. And the question is, how do you implement the rollback, and how effective is that rollback?

I want to say something to you that scientists normally say. We have two major activities going on right now. The second component of the Antarctica experiment is being put together right now. We will have that experiment take place over the next few months.

And by the fall—or excuse me, the winter—we will be able to get a better handle on the chlorine process down in Antarctica to see whether it's man-associated or not.

The second thing that is going on is the issue about the satellite data. If I could summarize it quickly, if you use the current theory, we should not be able to see any effect of ozone right now. It is too early.

If you look at satellite data, satellite data say, by a factor of two or three, we are seeing ozone depletion greater than what theory predicts.

A scientific team has been put together, made up of scientists from the academic community, NOAA, NASA, National Science Foundation, to look at the backscatter ultraviolet data taken from satellites, and to see whether those satellite data are real, or whether there are artifacts in them. Or whether the land-based measurements are the more appropriate ones.

All of that will be done in the next six months. So we are sitting at a point where the technology and the measurements are coming together. And as you say, the scientists always say that. Just one more tweak of the knob and I will give you the right answer.

But we are at a point where, I think, we can see some indicators one way or the other. The thing that concerns us in NOAA is that if you go ahead and take the brackets off what was brought back from the international protocol, you may find it more difficult if a greater rollback is required to get it.

It would be harder to move from 50 to 90 percent, or 85 percent, or 80 percent, than if we wait a little while, and see what that number possibly ought to be.

The same is true is we do not have to go that far; if we put 50 in place, and 35 is appropriate, as best we can understand right now. It is going to be very difficult to move that 50 once it is cemented into place in the international arena.

Senator **Kerry**. I would probably understand and be more sympathetic with the answer you have just given me if it were not for the fact that there was an original different position.

If you just came to me and said, this is why, this is the rationale of what we arrived at. But I understand the original push was for a 95 percent reduction.

Dr. **Calio**. Up to.

Senator **Kerry**. Up to?

Dr. Calio. Up to 95 percent in 10 years. That was the original objective. The original objective was, up to 95 percent rollback, from '86 standards, over a 10-year period. Up to.

Senator Kerry. Right. I understand that.

Dr. Calio. But I do not think we went in with a fixed number. I do not think that was the objective, going back to the original circular.

Senator Kerry. I understand, but again, I think there is a difference. If you are going to try for an up to 95 percent reduction——

Dr. Calio. Over ten years.

Senator Kerry [continuing]. Over ten years, I think most people understood that you wanted to achieve the 95 by the end of the ten years; correct?

Dr. Calio. If the science supports it, yes.

Senator Kerry. That was the goal, that was the best goal?

Dr. Calio. If supported by science.

Senator Kerry. And what you have come out with is a 20 percent reduction up to, what, 1990?

Dr. Calio. Two years after initiation.

Senator Kerry. Correct. And then six to eight years later, you may follow with an additional 30, but only if there is a subsequent agreement. Now that is a very different position.

Dr. Calio. Well, one is positive and one is negative. I guess the six years——

Senator Kerry. One is stronger and one is softer.

Dr. Calio. One is automatic and one is not.

My position on that, if I would follow the logic that you put forward, is, we ought to base that decision on the science; not make a policy decision before we look at the scientific results.

Senator Kerry. Can you share with us what role J. Roy Spradley had with respect to this?

Dr. Calio. He is on my staff, and I was not able to go to that meeting in Europe. I would have. I was not able to attend all of the meetings in the executive branch where I was requested to participate. And he went instead, with a scientific team, and with other members of the Department of Commerce representing trade.

And everytime there seemed to be some difficulty, he came back and talked to me and received guidance from me.

Senator Kerry. Is there any particular reason why he was chosen to do that?

Dr. Calio. Well, he is on my staff; knows this arena reasonably well from a legal standpoint. He is conversant with a lot of the scientific aspects. And he seemed to be a knowledgeable person to put on the job.

Senator Kerry. Were you aware that he was probably the principal architect of White House opposition to acid rain reductions, emission reductions to do with acid rain?

Dr. Calio. When was this?

Senator Kerry. During the period that Secretary Watt and others, in the early days of the administration, and ongoing, as a matter of fact.

Dr. Calio. Well, that is interesting. I sit on the council for the national acid precipitation program, personally.

And yes, J.R. does staff me on all that. However, the director of research is a fairly prominent scientist by the name of Larry Kulp who spent many years in geochemistry and forestry.

He was the vice president for research at Weyerhauser. He runs the research program for NAPAP, and reports to Lee Thomas, myself, Agriculture, Energy, and Interior.

Yes, J.R. Spradley does support me as a staff member in going to those meetings. But I attend those NAPAP meetings myself. And I interact with Lee Thomas a lot personally.

We cannot attend all the meetings that are going on as far as environmental assessment and regulation is concerned. But Lee and I talk a great deal.

Senator **Kerry**. I am going to turn it over to Senator Pressler in one moment. But is it fair to say that there were in fact a series of meetings between OMB, State and the EPA regarding this subject, and that it was subsequent to those meetings that there was a shift in the actual approach to the talks?

Dr. **Calio**. There were a whole series of meetings.

Senator **Kerry**. February. I am referring to February where there were some meetings.

Dr. **Calio**. Well, we can go back to December. I don't have those data with me. But I think from December on, I think there has been a discussion in trying to figure out what the best position was for the United States.

And we could supply that for the record if you want it.

[The following information was subsequently received for the record:]

INTERAGENCY MEETINGS REGARDING A PROTOCOL TO THE VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER

During the past year, NOAA participated in a number of interagency meetings regarding a protocol to the Vienna Convention for the Protection of the Ozone Layer. The NOAA representative at each of these meetings varied based on its topic and purpose. At some meetings, I represented NOAA. At others a member of my staff or the Office of Oceanic and Atmospheric Research represented NOAA. The types of meetings and their timeframes are identified below.

Interagency meetings were conducted by Department of State in 1986 leading to the November 28, 1986 decision to participate in negotiations of a protocal to the Vienna Convention for the Protection of the Ozone Layer at a meeting in Geneva on December 1-5, 1986. Interagency meetings conducted by the Department of State were also held prior to negotiations in Vienna on February 23-27, 1987 and in Geneva on April 27-30, 1987.

Meetings of working groups of the Domestic Policy Council were held during February-June, 1987 to discuss the negotiations. Informational briefings scheduled by the Office of Management and Budget were held during March-April 1987, on scientific, technological, health, environmental and economic aspects of various proposals to protect the ozone layer under consideration in the negotiations.

Interagency meetings were also held as needed to coordinate scientific research on the ozone layer.

Senator **Kerry**. Fine, that would be good if you could. I would appreciate it.

I want to come back to some more mundane questions with respect to overall policy in a moment.

But I will turn it over to Senator Pressler for his round first.

Senator **Pressler**. Thank you.

As I understand it, NOAA's fiscal year 1988 request does not provide funds to operate Landsats 4 and 5, or to archive, process and distribute data from these previous Landsat satellites.

I understand that this action was taken because the three-year nominal design life of Landsat 5 was scheduled to expire in March, 1987.

With Landsat having surpassed its scheduled expiration date, and with Landsats 4 and 5 showing no apparent signs of failure, what actions is NOAA taking to ensure that there will be adequate Landsat operational funds for fiscal year 1988, and when will NOAA resolve this issue?

How much will NOAA need in fiscal year 1988 to carry out these operational activities?

I have asked you two or three questions there. If you want me to repeat them, I will.

Dr. **Calio**. No, that is all right. I will answer them all.

We are in the process of preparing a paper going to the department and to OMB asking for additional funds to operate Landsats 4 and 5, for the very reason you suggested: they are lasting longer than their design life.

We estimate for fiscal year 1988 approximately $30 million are required to operate those for the next year, including the archiving activities associated with it.

I think those are all the questions you asked.

Senator **Pressler**. Well, how much will NOAA need in fiscal year 1988 to carry out these operational activities?

Dr. **Calio**. $30 million.

Senator **Pressler**. $30 million. Now, let me ask if there is any real question as to the merits of providing operations money for the two satellites functioning today.

Is there anyone you know of—in the Federal Government or elsewhere—who feels we should not?

Dr. **Calio**. There must be. No, I do not speak for my leaders. But I think the big concern was, nobody wanted to put the money on the table, that the satellites were not going to survive.

It looks like the satellites are surviving, and I do think the funding will be forthcoming.

These are very difficult budget times. So I think we will have to defend that, and move that request forward.

Senator **Pressler**. I understand that the Administration is considering the question of operations funding for Landsats 4 and 5 within the context of the commercialization issue.

What is the rational behind tying those two issues together? Perhaps even more specifically, if we were to assume the worst case scenario for the outcome of the commercialization issue, and we were to have no follow on satellites, should we pull the plug on the two operating satellites we have in orbit today?

Dr. **Calio**. I have not heard any negative comments about 4 or 5, and tying it—I mean, me personally, and all of the interaction I have had with the department and OMB on tying those two together.

And if the worst case happens for Landsat 6 and 7, and 4 and 5 were still alive, we would fund and operate 4 and 5.

Senator **Pressler**. Is it your opinion that the commercial operator or the Federal Government should be responsible for the operating budgets of Landsats 4 and 5?

Dr. **Calio**. Well, that is the patten we have set, and the answer to that would be yes.

Senator **Pressler**. That would be that the commercial operator or the Federal Government?

Dr. **Calio**. I am sorry. The Federal Government. I am sorry, I only got the last part of that.

Senator **Pressler**. Turning to the issue of commercialization, I am going to start at what I believe is the heart of the issue. In your view, can the Landsat program be established as a viable, going, commercial concern in the foreseeable future?

Or will it require ongoing Federal support, beyond Landsat 6 and 7? I guess I know the Administration line on this question, but would be interested in your professional opinion as someone who is intimately familiar with the current and potential commercial market for Landsat data?

Dr. **Calio**. That is a very complicated question. I am not sure I can give a simple yes or no answer. Lots of things have happened in the last year, as you know.

We have the French on line, and the Japanese coming out with their systems. We have had a Shuttle failure. We have had the opportunity of a platform where many different users could use that platform, and have it serviced in space by Shuttle astronauts, go away, at least for the time being.

And I have to come back and ask the question: when do you think, if ever, we have a Western test range that will launch a Shuttle that will allow us to service expendable satellites?

And when you answer that question, I will answer you when I think it is commercially viable. Because I think that is what it takes.

Unless we find ways in which to reduce the costs of manufacture and operation of these satellites, and the development of the new instrumentation, I think we are going to be hard pressed until we have a lift capability that can seriously reduce the operational costs of the satellites, to make it competitive where they can actually gain a profit from the sale of the data products.

Senator **Pressler**. Now, in your professional opinion, based on what you know now, is a one-satellite system or a two-satellite system the proper course of action for us to take?

Dr. **Calio**. I am going to have to stay with the party line on that. We have submitted a package of two satellites to OMB. OMB previously had submitted one satellite to the Congress, which was turned down.

I guess I should get this sequence right. We had a one-satellite program submitted to Congress to be considered. The Senate did not accept that proposal.

We—the Commerce Department—sent a two-satellite proposal to OMB, and we are currently discussing that course of action with OMB right now.

Senator **Pressler**. What is the real bottom line on what we can expect—when we can expect some decision on the part of the Administration? And can you give us any additional insight as to what that decision might be?

Dr. Calio. Senator Pressler, it has been a very difficult issue for the last two or three years on timing, timing particularly.

I would like to say within the month, well within the month. Because we have had fairly active dicussions with OMB in the past week or two. And I think a course of action could come out of that fairly soon.

I do not want to prejudge what OMB will do.

Senator Pressler. Will we have a Landsat program next year?

Dr. Calio. If 4 and 5 exist, yes, for sure.

Senator Pressler. Assume we just cash in the chips and scrap the Landsat program. What impact would the loss of that program have on our nation's scientific community, and our fundamental research programs in the area of global systems study, land resources analysis, and so forth?

And what would it mean to our international standing in the scientific community?

Dr. Calio. There would be some loss because of the analysis that goes along with space observing—observing the land forms from space.

As far as the global change is concerned, we still have many other satellites, and many other measuring platforms that can provide information about global change.

We have the Metsats. NASA is developing a TOPEX. There is an upper atmospheric research satellite being developed. There are several programs under way that will contribute data about the atmosphere and the oceans and the lands.

We have an exchange program with the European Community and with the world as far as exchanging oceanographic and atmospheric data.

So I think the global change activities can be carried out reasonably well. I think many of the measurements and thrusts that have been characterized in Francis Bretherton's assessment of the earth systems studies could be carried out, somewhat diminished, but we could still make headway.

Senator Pressler. I understand that about 200 Western European research and training establishments have established the European Association of Remote Sensing Laboratories, the purpose of which will be to initiate joint research programs and to promote collaboration and training where the technologies are likely to be deployed.

What are the implications of this association in terms of world leadership in remote sensing? Would such an association in the U.S. be practical or desirable?

Dr. Calio. Well, I think we still have a very strong capability in this country for developing technology. And the question you are bringing up is putting together a group like this that will develop remote sensing applications. That is their objective.

So from the technology standpoint, I still think we will see technology develop very well, and at a reasonable pace.

Where we have always fallen short in this country is in the application and development arena, the dollars that are spent to analyze these data and to come up with the techniques that are necessary to solve a problem.

I think we have, although we may not have it in the form of an association or a recognized forum, I think we have such groups already working in the United States to that end. The one that pops right into my mind is the Photogrammetry Congress in the United States. It is a tremendous, large organization, and they deal with analyzing remotely-acquired data, and how you use that for production of maps and analyzing land forms and the like.

If I really stop to think about that, there are many such associations already in place in the United States, and I do not think an additional one is necessary.

Senator PRESSLER. I see my time is nearly up, but I will ask one more question, if I may.

Now that the Shuttle launch complex at Vandenburg Air Force Base has been, for all intents and purposes, deactivated, at least until 1992, what contingency plans is NOAA making in the event there will not be Shuttle-based man-tended capability to service the space station polar orbiting platforms?

How would the absence of this man-tended feature affect NOAA's plans for use of these space station polar platforms? And to what extent would it affect the actual development of NOAA's sensors and other instruments?

Do you have any reason to doubt that these space station polar orbiting platforms will actually be launched?

Dr. CALIO. You are projecting about 10 or 15 years in the future. I am not sure I am capable of approaching answering some of those.

We are tied to NASA on supporting the development of its polar orbiting platforms, coming out of the space station program.

Up to now, we have looked at about the 1995 timeframe for bringing our operation on expendable satellites to a conclusion around 1995, and then the future would be the free flying polar platform.

If that gets pushed back then we would probably end up buying a couple more expendable satellites to fill the gap.

We would not back away from the platform. We think that is the right way to go. It offers a tremendous opportunity for us, as well as putting other people on that platform, and sharing costs.

And so we would be vigorously supporting that, sir, and developing such a program, and plan to be a very major participant.

Senator PRESSLER. I would like another round when you finish, Mr. Chairman.

Senator KERRY. Doctor, the first GOES NEXT satellite, I gather, is due for launch in 1989 October. Are you confident at this point in time that both the satellite and instruments will be ready?

Dr. CALIO. I am as confident as I ever am at this point in time with any satellite development program. We are doing everything we possibly can. I am not being glib when I make that statement. We are very nervous about the time and what we have to do. We share that concern with our own management team. NASA understands that with us. We have been to Ford. We have worked the problem. We have gone over all of the detailed management plans for those five satellites.

We think we have an approach that will get us there in time and we are working that problem.

Senator KERRY. Are you taking any special kind of steps with respect to the contractor and subcontractors to ensure the performance?

Dr. CALIO. I think we have, but let me ask Tom.

Mr. PYKE. We have performed additional reviews and more intensively reviewed the progress during this period of time in which questions have been raised with regard to performance and schedule. And we in NOAA, together with NASA, together with the contractor team, are doing everything possible to make sure that our GOES NEXT series, starting with GOES-I, will be ready to fly on schedule.

Senator KERRY. Now, you have decided to proceed with the procurement of launch services for that generation of satellites. In light of NASA's difficulties of the past year or so with satellite launches and in light of the expertise that they have, can you share with us the thinking that makes you believe that you can safely proceed with your own launch services procurement?

Dr. CALIO. We are buying launch services.

Senator KERRY. You are what? I missed that.

Dr. CALIO. We are buying launch services completely, and that is why we feel fairly comfortable in doing that. We are not just buying a launch vehicle and taking care of it ourselves at that point in time.

A tremendous capability and skill rests with the manufacturers, does now and always has over the past 25 years, in carrying out the launch arrangements for spacecraft. What we have to work out in detail—and we are in the process of doing that—is the hand-over between launch and operations, and how are we going to take care of that, because in the past the NASA people have come to our operations center and we go through the launch sequence there, and then they hand over the spacecraft to us during the launch sequence, because they have the communications network worldwide.

We have to rework that plan now, but as far as the launch skills are concerned and launch services that we are buying, we feel comfortable. We have the Air Force supporting us. We believe we are carrying out the administration policy, the decision that was made several months ago, in stepping forward and trying to ensure a vital commercial expendable launch services business. And we are a reasonable customer.

Senator KERRY. You are confident that you will have enough personnel assigned to that process to provide the oversight necessary to make the judgments about the choices with respect to those services?

Dr. CALIO. Yes, sir. We have assistance of the Air Force right now, and we have used the background of NASA in some respects.

Senator KERRY. It was my understanding that there were going to be some reductions in the numbers of those personnel or that they would not necessarily be adequate personnel, but you are saying that you have no problem, that there will be?

Dr. CALIO. I am sorry. I do not understand the question.

Okay. I see what you are saying. Well, let me give you another example, I guess, to make sure we are not plowing new ground here. I think Intelsat, when it buys launch services, does it with a very small team. They buy the entire operation, launch vehicle, and they do it with about five to ten people, and they buy the launch service.

In the past, we have not been buying launch services. It has been a very complicated system where we would go to NASA and they would buy the launch vehicle that would be delivered to their or the Air Force's launch complex, tied together through a NASA communications system, launched, overviewed by a NASA team. And we are trying to see if we can get that reduced and get it over into the hands of a commercial operator.

But the operation control center was ours and always has been, as far as checking out the spacecraft and operating. We just had NASA operators sitting next to us.

Senator KERRY. Now, the question has been raised by some about whether or not NOAA has the legal authority to contract for these services.

Dr. CALIO. Legal authority is okay. I guess the question is the multiyear funding. How do we go about doing it?

Senator KERRY. But you would have the legal authority to award a launch contract?

Dr. CALIO. Yes, if we had all the money right now. We do not have multiyear funding authority, so in the event that we do not get that—and we have papers working to try to gain that authority—we would have to come in with some sort of a large budget request to make sure that we covered the entire cost of the launch vehicle services over the time period of those services, all up front.

Senator KERRY. Is there a backup plan in the event something goes wrong as to the launch so you minimize the chance of a gap with respect to the service?

Dr. CALIO. I am sorry, Mr. Chairman. I do not understand the thrust of your question.

Senator KERRY. Well, assume that something went wrong in the contracting process or that somehow there was some sort of launch snafu. Is there any kind of backup plan so that you would minimize the gap in service with respect to the GOES mission?

Dr. CALIO. Well, it would be the same thing that NASA has used in the past if they had a procurement problem or they had a launch failure. We would just have to recycle into the next launch vehicle or delay the launch. And we have experienced both of those events in the past.

Senator KERRY. One of the later witnesses in prepared testimony notes that the National Center for Atmospheric Research has developed a sophisticated balloon-borne measurement system that can be operated by a single person and could be conceivably fully automated. Has NOAA examined that system or other new technology for taking quantitative weather measurements?

Dr. CALIO. For soundings? Yes. That was one of the things I commented about in my opening overview. We have and we are buying now 30 profilers, which sound from the ground. We are putting those in a test configuration in the middle of the United States in the next year or two. We will test their performance. We are developing or attempting to develop another type of profiler that will measure temperature and moisture. And if all of that works well, then we will be able to marry the data obtained from profilers, the sounding of the atmosphere, from the bottom-up with satellite data, where we sound from the top-down, and have a complete temperature, pressure and moisture profile through the atmosphere without deploying radio sondes.

So we are looking at new techniques. Now I do not know about this one with NCAR. Joe?

Dr. FRIDAY. I believe, sir, you are referring to the CLAS system, the system that NCAR has developed. It is a very good system that is being deployed now in research mode and we are using it in association with the severe storms laboratory at the University of Oklahoma now on a mobile storm spotter network and using it very successfully.

We have not addressed that as an overall replacement for a wind sounding system or an upper air sounding system in the National Weather Service simply because we are looking forward to the time period in which we can replace the balloon-borne sounding systems completely with remote sensing equipment. That unfortunately has been a little elusive for us. We were much more optimistic that we would be able to do it much earlier than we are actually realizing that.

But, as Dr. Calio pointed out, we are moving forward on both the wind sounding, wind profiling capability as well as the thermodynamic profiling capability and I have not examined it personally as far as an actual tradeoff with the existing balloon-borne equipment as to whether or not it would make economic sense to do a replacement, an interim replacement, before we went to a completely profiler-based system.

Senator KERRY. Are you going to be doing that?

Dr. FRIDAY. We had not planned on doing that. Simply we are waiting for the outcome at the present time for the wind profiler demonstration network. The best of all possible worlds would be to eliminate that balloon entirely.

Senator KERRY. Folks who are far more expert than I point out that despite the existence of satellites and the great wealth of information we get from them that conventional quantitative measurement systems from buoys to balloons to other things are still a very important part of the mix. Are you folks doing anything special to upgrade the current systems for taking measurements? You agree with that statement, I take it, about their importance.

Dr. CALIO. Yes, until we get the profiler or something like that in place, absolutely.

Senator KERRY. What are you doing to upgrade the current quantitative measurement-taking systems?

Dr. FRIDAY. The observing systems, from the National Weather Service perspective, of course, one of the major upgrades that we are going through at the present time is the automated surface observing equipment. That is the ASOS program that we are currently working with the FAA on and basically developing a capability of putting approximately 1,000 of those units around the country.

That replaces antiquated observing equipment that is operated by the human observer with basically a system that will be totally automated, with the possibility of a human observer adding remarks in those situations where the automation simply cannot perform effectively, although we are finding, as we develop that capability, that it is at fewer and fewer locations and fewer and fewer parameters that we cannot adequately measure with the automated system.

We are continuing to develop additional capability in the buoy area, with better instrumentation on the buoys, better instrumentation on the coastal observing platforms and systems that we have installed around the coast of the country. And we are better equipping the National Weather Service totally across at least the 48 contiguous States with the NEXRAD system, which will provide us with an overall capability of measuring detailed parameters both at that location as well as remotely.

Those systems are upgrading the observational capabilities quite a bit. I agree with your statement and those that have given you the information stating that in situ measurements are still vital for us, for calibration of the remote soundings, for filling in the sort of detail that at the present time we simply cannot obtain from those soundings, although we are making significant improvements in those areas.

Senator KERRY. Thank you very much.

Senator Pressler.

Senator PRESSLER. I shall just ask one more round, but let me say, Mr. Chairman, that Senator Lugar has requested me to submit on his behalf questions for the record on the next generation weather radar program to be answered for the record. So I would ask unanimous consent that Senator Lugar's questions be submitted for the record.

Senator KERRY. Without objection, they will be, and we will leave the record open to receive those answers.

Senator PRESSLER. Now, Dr. Calio, I am not clear as to your response to my earlier question on the commercial viability of Landsat. Let me try it again. In your professional opinion, do you think Landsat is commercially viable in the foreseeable future? We all understand there are many variables and uncertainties involved, but just give us your best reaction as to whether you yourself would get in as a commercial operator in the business if you had a choice.

Dr. CALIO. I do not see how you can expect me to answer that question. You just said it. You just put the condition on it. There are many variables associated with this.

Senator PRESSLER. Well, based on those variables as you know them to be today.

Dr. CALIO. Beyond our control. And I think businessmen like to have the external forces at least within their control.

Senator PRESSLER. So, therefore, they would not get into it commercially?

Dr. CALIO. You know, I am not a businessman, and so it is very hard for me to answer that question at this point in time.

Senator PRESSLER. But based on your best professional opinion you would probably conclude then, because of the number of variables and uncertainties——

Dr. CALIO. That I would not want to answer it.

Senator PRESSLER. That you would not get in as a commerical operator. This is a very serious matter.

Dr. CALIO. I know it is.

Senator PRESSLER. Because the administration is saying that this will all be commercialized and I just do not think we can rely on the prviate sector, by itself, to keep the program alive. Would you agree with that statement, with all the uncertainties and variables?

Senator KERRY. Why don't we just let the record show that he laughed when asked the question?

Senator PRESSLER.Yes. Well, if it is not commercially viable, then would you conclude we ought to have a policy of the government doing it?

Dr. CALIO. No, absolutely not. We have put $1 billion of research into Landsats and the like, and I think we would have to step back and take a look at what is on the table. I have listened to you talk about maintaining U.S. technological leadership. I am not worried about sensor technology leadership in the United States in civil sensing or in remote sensing from space. I think the United States is the leader today and always will be as long as we continue to do some of the things that we do. And that technology will be developed.

The question comes back now to civil applications, the use of that data for civil purposes. And that is where your thrust is, as far as I am concerned, on the business end of it. And we have put over $1 billion into it, and you have to ask yourself the question, is $400 million or $500 million over the next two or three years worth that stake in civil application development, because that is the question you are asking—not on technology of instruments. The United States will stay there.

I think there is one other question that you have to step up to, and that is one of what will happen to the concept of nondiscriminitory use of or sale of the data. The United States has been a leader there and has set forward a policy and has practiced that the data collected by civil remote sensing satellites is readily available to anyone at a nondiscriminatory price, so it is uniform.

Now the Japanese have not stated what they are doing. The French are adhering to that policy for now. If the United States is no longer in the civil remote sensing business, whether private or public, I am curious what will happen to that policy.

Senator PRESSLER. Now according to your statement, about $12 million of NOAA's $54 million increase in funding for its polar-orbiting Metsats is driven by changes in the instruments and communication characteristics of the NOAA J, K, L, and M spacecraft. What is the nature of these changes and how will they improve the capabilities of these NOAA Metsats? Do they represent a state-of-the-art improvement in their respective capabilities?

Dr. CALIO. Yes, they do, and I am going to ask Tom Pyke to give you a detailed answer to that.

Mr. PYKE. Senator Pressler, we are planning some new instruments in our NOAA K, L, and M series of polar Metsats. These are the AMSU instruments, which provide a much better soundings capability.

Dr. CALIO. What does AMSU mean?

Mr. PYKE. Advanced Microwave Sounding Unit, or AMSU. At the same time, there will be certain older instruments, such as the

SSU, the Stratospheric Sounding Unit, for which we do not have enough to go into the K-L-M series, and which will be supplanted by the newer instrument, which we will not be carrying on our morning satellites, NOAA D and NOAA J, in the polar series.

So we are moving toward newer instruments and we are still carrying our full complement of instruments on our afternoon polar Metsats. Associated with the advances in the NOAA K, L, and M series of spacecraft will be improvements in the ground systems that support the operation of those spacecraft and the dissemination of data from them.

Senator **Pressler**. According to your statement, the sounding capability of NOAA-9 has failed. How will that affect our weather reporting and our nation's weather detection capabilities. In the interim is there anything that can be done to compensate for that failure?

What caused this failure, and what is the chance that this same failure could occur on the NOAA-10 and subsequent spacecraft?

Mr. **Pyke**. The failure on NOAA-9 in terms of the data necessary to generate soundings results from a combination of two instruments failing over the normal course of their life. One of these is the HIRS, an instrument that indicates whether we need to use microwave soundings data in order to produce soundings. And the other is the recent failure of the microwave sounder. Because of these two failures, which are consistent with the current point in the life of this satellite, we are no longer able to generate good soundings data from the NOAA-9 spacecraft.

We are, however, able to use soundings data from NOAA-10 on a backup basis to provide an interim input to the National Meteorological Center and we have proceeded full steam ahead to plan for the October 1987 launch of the next polar meteorological satellite.

Senator **Pressler**. What contingency plans is NOAA making for a backup vehicle to the commercial ELV that NOAA selects? Will the French Ariane ELV be a potential backup vehicle, or will the GOES satellites that will be launched on those commercial ELVs be designed to be dual-compatible with another vehicle? If so, which vehicle, and, if not, why?

Dr. **Calio**. Well, I cannot answer that right now, since I do not know who the winner is going to be, so I do not know what the interchangeability of those two are concerned. However, there is a notion among the two or three or four expendable launch vehicle manufacturers that within the realm of or the envelope of design for launch loads and other characteristics that there should be some interchangeability.

At the present time, we are not providing a dual capability for GOES because we do not know what dual capability has to be built in. When we finally make a selection, then we will take a look at whether there is a chance that we have another launch vehicle that is close to it that we might want to provide that capability and how much will that cost and how long will it take.

Senator **Pressler**. All right. As we all know, in years past the administration has opposed the idea of a two-satellite polar orbiting system for NOAA, preferring to rely on a one-satellite system. Is there any doubt in your mind now as to the administration's commitment to a two-satellite polar-orbiting satellite system for NOAA?

Dr. Calio. No, sir, not right now.

Senator Pressler. No doubt. All right.

NOAA's fiscal year 1988 budget justification states that NOAA will strive to achieve more economical application of polar-orbiting satellite technology for its programs through exploring commonalities in joint NOAA-DOD Metsat payloads.

Now, concerning NOAA and DOD Metsat payloads, you may also be familiar with the April GAO study that concludes that a national system of one NOAA TIROS satellite and two DOD DMSP satellites would be sufficient to satisfy our national meteorological needs. Furthermore, the same study recommends that DOD and the Department of Commerce take the initiative to converge the DMSP and the TIROS polar-orbiting satellite systems to the maximum extent possible.

Based on this report and on NOAA's budget justification, what actions are being considered toward the convergence of these two systems and what are the advantages and disadvantages of a convergence of these two systems?

Dr. Calio. Let me just see if we can touch the tops of those. First of all, this will make about the fourth convergence study we have done over about the last 16 years, and I think every convergence study says yes, it can be done, and you have to look at the individual policy needs of the various agencies involved. So it is a policy consideration and not a technical one.

And I am assuming that is probably where this one is going to end up. Maybe I should not be so bold, but usually what happens is the policy considerations become very strong. And the reason for that is in the civil community we have a tremendous exchange program internationally through the World Meteorological Organization of our data, so that we have access to data we could never collect. Of course, they have access to our satellite data from other countries. And that exchange program is very viable and very effective. And it is available to all people in the United States. So that becomes a very important policy consideration, to maintain those open lines.

As far as the detailed convergence studies are concerned, we are looking at three particular—one more point. You mentioned something in there about GAO always says you must look at commonality as much as possible. We are common today. We have done that. We did that ten years ago in buying the current TIROS satellites. We use the same spacecraft for DMSP as we use for the civil system.

The only thing that is different are the instruments. We make modifications to the spacecraft, DMSP benefits from it; the Defense Meteorological Satellite Program makes changes, we benefit from them. We have built the program that way over the past ten years. The instruments are different because our needs are different.

We have three thrusts for the future. I mentioned two of them. We are counting on the polar platform for NASA. We think that is the way to go technically. We think that is the way to go economically. We are not sure yet because we have not seen all of those concepts and plans. Two, if that fails or that is pushed back, we are prepared to buy two or three more expendable satellites.

At the same time, we are participating with one more convergence study with the Air Force and trying to set up the requirements for what would have to be looked at in that particular study. Tom Pyke is a member of that team and Tom may be able to give you the details of what is happening in that arrangement.

Mr. PYKE. We are looking both at the policy aspects of possible convergence of our civil meteorological satellites with the defense meteorological satellites and specifically looking at the possible opportunity to participate in a design study that DOD is planning to conduct to look at technological alternatives for meeting their requirements and possibly additional requirements such as those of our civil meteorological satellite program.

Senator PRESSLER. Mr. Chairman, I have several more questions for the record. I have had two rounds of questioning, so I will not seek a third round. But I ask unanimous consent to submit additional questions for the record.

Senator KERRY. Without objection, so ordered. And also, I might say that Senator Inouye also has requested to submit some additional questions, so that will happen. And I am also going to submit some additional questions, because we have taken longer than I anticipated. And we do have a distinguished second panel.

I would just like to ask a couple of things if I can before we move to the next panel. A lot of us from different regions of the country obviously are concerned about the hurricane warning capacity, and the flights by NOAA and the Air Force I think being cut back. There is some restraint there, at any rate.

Are the P-3 flights adequately budgeted for in the 1987 cycle, 1987-88?

Dr. CALIO. We have some problems in 1987.

Senator KERRY. Is there anything that can be done about that?

Dr. CALIO. Well, I will have to go back and look at how I can rework my budget, because apparently we do have a slight shortfall.

Senator KERRY. And I take it they are not fully covered for 1988 either?

Dr. CALIO. You are talking about the P-3's?

Dr. FRIDAY. Sir, one of the questions concerning this is where exactly in the budget process, in what Department, lies the funds for funding operational hurricane reconnaissance flights.

Those moneys were originally in the NOAA budget up until two years ago, up until last year, and they were transferred over to the Air Force budget by Congressional action. We are working with the Air Force now to make sure that those funds which were supposed to cover both the Air Force reconnaissance flights as well as the NOAA P-3 flights will be usable for doing just that.

We are still working with the Air Force on that. Our Office of Aircraft Operation is in negotiation at the present time.

Senator KERRY. The DOD request currently provides for about 1,000 hours, is that right?

Dr. FRIDAY. That is correct, sir, 1,000 hours.

Senator KERRY. Is that adequate?

Dr. **Friday**. That 1,000 hours is devoted exclusively to the Atlantic and Gulf Coasts, with no plans for any reconnaissance activity in the Pacific. We have had an average total reconnaissance time over about the past ten years of in excess of 1,000 hours. It is closer to 1300 or 1400 hours.

But that had covered a large number of additional DOD requirements out at sea, covering Navy requirements in central Atlantic and even part of the south central Atlantic.

The agreement there is that we will no longer fly reconnaissance missions for those. We will fly reconnaissance missions for support of the coastal zones of the United States for the protection of the U.S. population on shore.

1,000 hours in a good season will be adequate. In a bad season it will not be sufficient. And I am sure that between NOAA and the Air Force, one way or the other way, we will fly the missions and then worry about how to pay for them.

Dr. **Calio**. Let me give you a contrast over the two years. In 1985, 1562 hours; in 1986, 422 hours. So look at the variation of those two.

Senator **Kerry**. Okay. Well, we will obviously be thinking about that as we approach the issue also, I am sure.

In the storm surge simulation work that you have been doing last year, you reported to us that about half of the 25 key cities designated had been modeled. But I guess—let me be precise and not guess. Boston, Narragansett Bay, Buzzard Bay, New York, Long Island, and others had not yet been modeled.

Can you tell me now where we stand with respect to that and what we might expect shortly?

Dr. **Friday**. I had a suspicion you might ask that question in this hearing, sir. I have here the charts for Narragansett, Buzzard Bay, and also for Boston Bay. Phase one of both of those projects is now completed, which means that we have completed the initial simulation runs.

You will be happy to note that Boston Bay is situated such that the normal path of any hurricane that we have been able to track and simulate will not cause a major storm problem in Boston Bay. There will be quite a lot of wave action and wave damage, as I am sure you are aware, but there is not a storm surge problem in Boston Bay from the results.

The Narragansett-Buzzard Bay, of course, are directly in the path of most of the storms that move up the coast. There are significant problems.

We will have completed by September of this year the complete atlas on those and made available to the local emergency management officials. So those projects will be completed by the end of this fiscal year.

Senator **Kerry**. Fantastic. I think that is a terrific note on which to recess this panel.

But before I do, my colleague Senator Lautenberg has joined us, and I do not want to unfairly deprive him of an opportunity to ask any questions he might have.

Senator **Lautenberg**. Thank you, Mr. Chairman.

I am pleased to be here with you. I am not going to be able to stay. Dr. Calio and I are old friends and we talked about other issues, including things like Sandy Hook, New Jersey, which may not be familiar to you, Senator Kerry, but is a familiar issue to Dr. Calio and his colleagues and NOAA.

And if we can submit questions for the record, I would appreciate that, and I hope we get a response back.

And thank you, Mr. Chairman, for holding this hearing, and the witnesses for their appearance.

Senator KERRY. Without objection, the record will remain open, Senator Lautenberg. Why do we not leave it open for about—yes, Dr. Calio.

Dr. CALIO. With your permission, Mr. Chairman, since you brought up the question about stratospheric ozone, Dan Albritton, the head of our atmospheric chemistry group, has written an outstanding summary of the state of science. I would like to submit this for the record[1] if I may.

Senator KERRY. We would be delighted to have that and I think it would be very helpful to all of us as we learn more. It will be included by reference.

I did want to ask some questions about your current findings with respect to the Antarctic and where we may be proceeding. I am going to submit those in writing because we are running short on time.

And also, with respect to acid rain research, I was particularly curious. That is an area that I have had a lot of background in and I am interested to see us move forward on it. I would be very interested in having the answers to those.

I thank you all very, very much for your time and for your valuable insights on a lot of different issues. We appreciate it.

And I know you are going to go back and shake your head over LANDSAT 4 and 5 in the future. But thank you. We appreciate it.

[The following information was subsequently received for the record:]

U.S. DEPARTMENT OF COMMERCE,
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION,
Washington, DC., August 11, 1987.

Hon. LARRY PRESSLER,
Ranking Member, Subcommittee on Science, Technology and Space, Committee on Commerce, Science and Transportation, U.S. Senate, Washington, DC.

DEAR SENATOR PRESSLER: We are pleased to respond to supplemental questions resulting from the May 19, 1987 hearing on NOAA's satellite and atmospheric programs.

If you, or your staff, have further questions, please let me know.

Sincerely,

B. KENT BURTON
Director

Enclosure.

Question 1. What would be the consequences if no funds were made available for operation in FY 1988 of the present Landsat system—specifically, how would this affect the operations of Landsats 4 and 5, as well as the activities associated with archiving, processing, and distributing the data acquired from these and previous Landsat satellites?

Answer. Special Contract Requirement H-34, captioned "Special events", anticipates Government actions such as the proposed cessation of funding for current Landsat 4 and 5 operations. Specifically, H-34 provides for the parties to "attempt to mutually restructure the elements of this contract to achieve data continuity through July 16, 1994 and the successful commercialization of land remote sensing", if, among other triggering events, "[t]he Government qualifies or rescinds the day-to-day operating authority granted the Contractor" resulting in the Contractor's inability to achieve contractually expected revenues. EOSAT could agree to restructure the contract to fund current operations out of its revenues or company investment. These funds were not requested in the FY 88 budget because the satellites were expected to cease operating as they reached the end of their design lives. Cessation of operation of Landsats 4 and 5, in and of itself, would in no way affect EOSAT's contractual rights to market or sell existing Landsat data from EOSAT's inventory or the Government archive and to retain the revenues obtained from such activities.

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[1] The summary is in the Committee files.

Question 2. Is increased international cooperation in satellite land remote sensing practical or desirable?

What form might this cooperation take?

Would this be compatible with current U.S. policy towards commercialization?

Answer. There is a considerable amount of international cooperation in satellite remote sensing now and has been in the past. This is expected to continue and probably increase with the space station platform programs in the 1990s. The form of international activities in the future is difficult to predict, but it will be studied as a part of the overall study of future Landsat system alternatives. Possible partnership arrangements with other countries will be considered. Our approach to examining prospective partnerships will be to seek arrangements which reduce government costs, and we would not propose arrangements which would be incompatible with this commercialization policy.

Question 3. What would be the advantages and disadvantages of the U.S. relying on the satellite remote sensing systems of other nations?

Answer. The advantages of relying on the programs of other nations for U.S. data needs would be a reduction in program costs. The U.S. outlays would be for data purchases alone. Other countries are benefitting from our substantial investment in developing this technology. However, the United States would be at a disadvantage if any deviation from the "open skies" policy were to occur. Many U.S. data users have developed value-added techniques and data applications based on Landsat's unique special characteristics. If these users were to rely on data from foreign systems, some applications could be lost or could be more costly. Successful commercialization provides a method by which the U.S. Government can ensure that U.S. private sector systems and a wide range of data applications will be available to the U.S. citizens.

Question 4. Japan has just deployed its Marines Observation Satellite (MOS). To what extent is the data of MOS desirable to meet any U.S. civil or commercial needs?

Does the U.S. have or intend to get access to MOS data, and what restrictions, if any, are there in terms of U.S. access to this MOS data?

Answer. There is no information available on U.S. civil agency needs for MOS data, but several agencies have expressed interest in the data for research, development and applications studies. In addition, several U.S. corporations are believed to be conducting market surveys of both U.S. Government civil and commercial interest in MOS data products. If these surveys prove favorable, it is expected that discussions with Japan and its Remote Sensing Technology Center (RESTEC), the marketing organization for Landsat, Spot and MOS-1 data would be held.

Question 5. Should the U.S. be more active in coordinating and assuring access to foreign data systems, and, specifically, what is being done now?

Answer. The level of activity of the United States is adequate at the present time. If any change on the part of foreign data system operators or managers with respect to "open skies" occurred, then the United States Government would need to take a more active role. The policy of the United States, as stated more recently in PL 98-365, is a firm commitment to open, nondiscriminatory access to civil remote sensing data by all people. It is understood that the U.S. Government would take a more active role to ensure international adherence to this principle if any change from the current practice were to be evident.

The U.S. Government is presently coordinating access to ERS-1 data when it becomes available in the early 1990s. These data will be of a research nature from the European remote sensing system. In addition, numerous discussions on coordinating access to space station program data are in process.

Question 6. How much, if any, technical assistance do you expect from NASA and the Air Force in the commercial launch of the GOES, K, L, and M satellites?

Answer. NOAA expects that the US Air Force will provide substantial assistance in the evaluation of the proposals for the commercial launch of the GOES I, J, and K satellites (with options for L & M). This assistance will consist of Air Force technical and business experts who will serve on the NOAA Source Selection Advisory Board (SSAB), the Technical Evaluation Committee, and the Business Advisory Committee.

During the contract performance period, the Department of Defense auditors resident in the manufacturing plants of the contractor will be requested to perform checks of the proper performance of the work according to the contractor's normal quality control procedures.

Marginal costs to the DOD for providing this support will be reimbursed by NOAA.

Discussions with NASA are taking place to establish support levels.

Question 7. Could you compare the expected cost differential to NOAA in contracting for these commercial launches, as opposed to procuring the ELV hardware from NASA for the same launches?

What factors account for this cost differential?

Answer. There will be savings because of the reduction in the size of the Government's management team for this contract. NASA had planned to employ about 40 staff. NOAA will utilize a team of not more than 10.

Question 8. I understand that NOAA needs statutory authority to procure commercial ELV launches for the GOES satellites, because it presently does not have the statutory authority for "multi-year" procurement.

What is NOAA doing to rectify this problem, and what would be the consequences if NOAA did not have this authority?

What is the latest possible date for NOAA to receive this authority and not have the launch of the GOES I (eye) satellite not affected?

Answer. The Department is assessing various contractual arrangements for GOES launch services, including multi-year authority. Without multi-year or incremental contract authority, the Government would have to appropriate the entire contract amount prior to award, the level of which has not yet been determined.

Question 9. The fiscal year 1988 budget request for Next Generation Weather Radar (NEXRAD) development is $56 million. What is the total development cost expected for NEXRAD, and what are the expected annual operating costs?

How does the present projected total development costs compare with the original projected total development cost?

Answer. The fiscal year 1988 budget request of $56 million for the tri-agency NEXRAD program will fund the Department of Commerce share of the Limited and Full Scale Production phases of the program. Appropriated funds will be used for procurement of parts, manufacturing, completion of site surveys, land acquisition at selected NEXRAD sites, modifications and construction of facilities to accommodate NEXRAD equipment and related tasks.

Tri-agency total costs of the NEXRAD program are expected to be approximately $800 million (real-year dollars). Original projected total costs in 1980 were $856 million (real-year dollars), but current costs provide for 15 additional radar systems, 253 additional operator workstations and numerous other equipment and support requirements not included in the 1980 estimate.

Recurring NOAA non-personnel costs following full network deployment in 1994 are estimated at $9.1M per year (fiscal year 1987 dollars).

Question 10. According to the fiscal year 1988 budget justification, NEXRAD deployment is scheduled to begin in fiscal year 1988, with completion scheduled for mid-fiscal year 1994.

Are these programmatic milestones on schedule with the original NEXRAD schedule? If not, what is the difference, and what factors have contributed to the delay?

Answer. The production phase of the NEXRAD program is scheduled to begin in late fiscal year 1987 with initial deliveries beginning very late in fiscal year 1989. U.S. network deployment is scheduled to be complete in mid-fiscal year 1994. These milestones are approximately 12 months later than the schedule established in 1982 for program development and deployment. Four principal factors contributed to the schedule revisions:

1. Additional equipment quantities and other requirements referenced in the answer to question 9.
2. Evolution of the requirements of the three participating agencies during the development (validation phase) effort requiring additional time for contractor development and test.
3. Establishment in 1982 of a success-oriented schedule with insufficient time margins for resolution of development problems.
4. Sometimes inefficient contractor management of the development and test effort.

Question 11. According to the fiscal year 1988 budget justification, the Advanced Weather Interactive Processing System (AWIPS) budget request is $20.5 million. What is the total development cost for AWIPS, and what are the expected annual operating costs?

How does the present projected development cost compare with the original projected total development cost?

Answer. The total cost of developing AWIPS is estimated to be over $100M, including the cost of providing systems for a comprehensive demonstration program prior to a national implementation decision. Annual operating costs are estimated to be about $20M, not including amortization of capitalization costs.

The currently projected development cost is comparable to the original projected cost. That is, the projections are within the uncertainties that exist until formal competitive procurement solicitations have been completed and actual contracts negotiated.

Question 12. AWIPS deployment is scheduled to begin in late fiscal year 1990, with the completion scheduled in fiscal year 1994.

Are these programmatic milestones on schedule with the original AWIPS schedule? If not, what is the difference, and what factors have contributed to the delay?

Answer. AWIPS deployment is now scheduled to begin in fiscal year 1991 and extend over a period of 4 years as previously planned. This schedule has been delayed from the original schedule. The projected award of competitive Definition Phase contracts has slipped by about 8 months due to extension of the procurement process. The Definition Phase also has been extended by 2 months to provide added testing and benchmarking of competitive designs, and to accommodate a program change that requires a second competitive solicitation for the follow-on Development, Deployment and Operations Phases.

Question 13. The fiscal year 1988 budget request for Atmospheric Research, $37.7 million, is $6.6 million less than the fiscal year 1987 appropriation.

What are the reasons for this reduction, what are its implications for future atmospheric research, and which areas of focus are being deemphasized as a result of this reduction in funding?

How will this reduction in funding affect the current and future capabilities of the National Weather Service?

Answer. The NOAA fiscal year 1988 budget request for atmospheric research is a net reduction of $6.6M from the fiscal year 1987 appropriation. This decrease is composed of an $8.4 million programmatic decrease and a $1.8 million positive adjustment-to-base (primarily for pay raise and increased cost from the new Federal Employees Retirement System). This reduction is in lower priority programs and is in response to the national need for fiscal restraint.

Areas of atmospheric research affected by this net reduction are:

	Millions
The Program for Regional Observing and Forecasting Services [PROFS]	$2.0
Severe Weather Research	1.25
Federal/State Weather Modification Program	2.15
Meteorological Research Computer	3.0

Implications of the reduction in each of these areas are:

PROFS

After allowing for a decrease of $2 million, the remaining base of $2 million will maintain the PROFS facility and adequate support to the NWS for the implementation of AWIPS. Much of the PROFS mission in demonstrating techniques to integrate diverse data sets has been accomplished as evidenced by the initiation of the AWIPS program.

SEVERE WEATHER RESEARCH

This decrease will be achieved by postponing some lower priority aspects of OAR support to National Weather Service training programs; and deferring analyses of mesoscale convective systems, and some aspects of studies on smaller-scale severe thunderstorm-induced events and winter storms. NOAA will encourage university researchers to undertake studies such as these and will maintain its core expertise to utilize planned new observational capabilities (e.g. wind profilers, NEXRAD) in studies to improve understanding of, and forecasts for mesoscale weather events.

FEDERAL/STATE WEATHER MODIFICATION

A savings of $2,150,000 will be achieved through the termination of NOAA's participation in the North Dakota, Utah, Nevada, Illinois weather modification efforts. Results of such weather modification research efforts to date are inconclusive. This type of state-specific cloud physics research is more appropriately undertaken and funded by the individual states.

METEOROLOGICAL RESEARCH SUPERCOMPUTER

Elimination of the $3.0 million one-time non-recurring FY 1987 add-on for a meteorological research supercomputer at the Mid-America Research Institute in Norman, Oklahoma (p. NOAA-39).

QUESTIONS OF SENATOR LUGAR AND THE ANSWERS

Question 1. What factors will determine which network radar-designated weather service offices will be closed or scaled back?

Answer. There is no simple answer to this question. Detailed discussion of the factors relating to the new radar network and field office operations must be viewed in the broader perspective to be presented in a modernization plan for the National Weather Service which will be transmitted to the Congress in the near future. Relevant background information is summarized here.

During the last several years, NOAA has undertaken intensive technical planning to integrate major new technologies for observation of destructive weather phenomena, analysis of weather and hydrologic data from all sources, and timely dissemination of warnings and forecasts to the public and user agencies. These major technologies which will form an interlocking system to provide weather warnings and forecasts include NEXRAD Doppler radar, the Automated Surface Observing System (ASOS), AWIPS, ground-based wind profilers, as well as major meteorological satellite and supercomputer upgrades. The fundamental purpose of the modernization of virtually all of the major NWS technologies is to improve weather and flood warnings and forecasts to the public, particularly for the most destructive weather events.

During the course of technical planning, it has become obvious that the entire operational and organizational structure of the NWS will have to be adjusted in order to utilize the new technologies effectively to meet the goal of improving weather warning and forecast services to the public. A plan for an integrated modernization of the technologies and operations of the NWS are currently under review within the Administration. In particular, proposals for operation and siting of NWS radars in the 1990s will reflect a complex range of factors based upon the new capabilities of all of the major new technologies as well as the practical organizational factors relating to the delivery of new and improved warning and forecast services to users.

NEXRAD radar performance and coverage are very important components of the design of the NWS of the 1990s, but the location and operation of NWS field offices will not be determined solely by radar network considerations.

Question 2. Have you established a procedure to accommodate community objections to the planned closing or change in status of a WSO?

Answer. As discussed in the response to question #1, final proposals for the modernization of the NWS will be presented for review by the Congress in the near future. Because the purpose of the nearly decade long, billion dollar modernization is to significantly improve weather and flood warning and forecast services, it is expected that all communities served by the NWS will receive improved services in the 1990s.

Question 3. How will a community currently served by a locally-sited WSO receive data from a "super WSO" based some distance away?

Answer. This question seems to be based upon the operating concept of the current NWS structure. As discussed in the response to question #1, the current NWS structure will be outmoded by the major new technologies of the modernized NWS of the 1990s. The key emphasis on technical planning of the modernized NWS has been to design an effective way to get new weather and flood warning and forecast "data"to users in the most timely and understandable fashion. Internal communications between NWS offices will be accomplished by the new AWIPS system. Detailed discussion of service improvements will be contained in the modernization plan for the National Weather Service that is currently under review.

Question 4. Please respond to the concern that a city without a Doppler will be inadequately served because priority will be given to the area immediately surrounding the Doppler site.

Answer. All cities will have Doppler coverage in the new network, even though the radar antenna may not be physically sited there. As discussed in the response to question #1, the operational use of the Doppler radar by NWS field offices in the future will be different in several critical ways from the current use of non-Doppler radars. First, the NEXRAD radar network coverage will extend to every population center in the United States, because the power and sophistication of the NEXRAD system exceeds by far the capabilities of current systems. Second, the intergration of NEXRAD data with meteorological satellite data and inputs from the network of automated surface observing instruments will be assisted by a complex new interactive computer system (AWIPS). AWIPS will allow the forecaster to assimilate all relevant weather data from the entire area under the responsibility of a new field station. In fact, this system will help identify dangerous weather developments whereever they may be forming; it does not "favor" the area immediately surrounding the radar antenna.

Question 5. Which current network radar-designated Weather Station Offices will not be Doppler sites?

Answer. As discussed in the response to question #1, comprehensive proposals for the modernization of the NWS are currently under review and are expected to be submitted to the Congress in the near future. Final decisions on NEXRAD Doppler radar deployment will be presented at that time. Two important factors should be emphasized here. First, the new Doppler radar network has different operational performance characteristics than the existing (network and local warning) radars, such that one-for-one replacement of the radars or cost effective strategy. Designing the new Doppler radar network based upon Doppler radar capabilities has been the approach taken to obtain improved coverage of every area of the United States. Second, the NEXRAD Doppler radar network is a tri-Departmental (Commerce, Defense, Transportation) effort in which the stringent weather radar requirements of each Department have been met successfully in the most cost-effective manner.

Question 6. Of those, which will be covered by a Doppler located more than 25 miles away?

Answer. Once final siting decisions have been made, such information will be available. The distance of 25 miles has no apparent relationship to the expected operational characteristics of the NEXRAD Doppler radar. In general, excellent Doppler radar performance is expected at several multiples of the 25 mile distance cited in the question.

Senator KERRY. Without any recess or anything, I would like to move on into the next panel, if we can. I would ask our panelists if they would take their places. Thank you.

Gentlemen, welcome. What I would like to try to ask, if we can, and I do not want to unfairly—you have all been very patient. You have taken the time to be here, and we want to hear your testimony.

If it is possible to summarize in five minutes or so, it would be helpful to us so that we could have a chance to have some questions. And we are going to be running tight in total time, because I have to join my colleagues at a caucus before too long.

So have you decided on an order, because I am very open. We can go from left to right or right to left, or center to both sides. Why do we not start over here, Dr. Sorooshian.

STATEMENTS OF DR. SOROOSH SOROOSHIAN, PROFESSOR, DEPARTMENT OF HYDROLOGY AND WATER RESOURCES ADMINISTRATION, UNIVERSITY OF ARIZONA IN TUCSON; DR. D. JAMES BAKER, PRESIDENT, JOINT OCEANOGRAPHIC INSTITUTIONS, INC., WASHINGTON, DC; DR. KERRY A. EMANUEL, CENTER FOR METEOROLOGY AND PHYSICAL OCEANOGRAPHY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY; AND DR. ROBERT G. FLEAGLE, DEPARTMENT OF ATMOSPHERIC SCIENCES, UNIVERSITY OF WASHINGTON, SEATTLE, WA

Dr. **Sorooshian.** Thank you very much, Mr. Chairman.

My name is Soroosh Sorooshian and I am a professor at the Department of Hydrology and Water Resources Administration at the University of Arizona in Tucson, and I am going to be speaking with over ten years of experience in teaching research in the field of hydrology and water resources.

I really do not know how many times hydrologists get a chance to testify in Senate committees, and other Congressional committees related to their state of affairs, and I find this to be a unique opportunity to express some of the concerns of the scientific side of hydrology, with respect to the budget cuts in our research programs, and also with respect to the flood and water resources forecasting issue.

The fresh waters of this nation are of course important in respect to the economic growth and wellbeing. The demands are growing at all times, and we would expect both better quality and larger quantities of water to meet the extra demand.

Structural alternatives, such as building dams and reservoirs, aqueducts and so on, are no longer as viable as they used to be because many of the good sites have already been used. We are finding ourselves with environmental issues that prevent some of the sites from being built to meet the additional demands.

So what needs to be done, of course, is to place more emphasis on non-structural alternatives, such as better management (demand management) of the existing structures.

As it is, floods and droughts do create dramas and they do make news, but every day, we make water resource management decisions. But we need better mechanisms to do that. For example hydropower generation and low flow releases for water quality concerns, barge loading decisions, etc., are daily decisions that water resources and barge company managers have to make. In the agricultural sector, farmers have to make certain decisions that depend upon what are the forecasts of the future amounts of water in rivers and so forth.

So, if we do not pay attention to the urgent needs for improved water resource forecast services for the country, we may experience serious consequences down the road. Despite this recognition of the urgency for development of the scientifically based techniques to better manage our water resources, Federal support for basic research has unfortunately declined over the past several years.

The scientific community strongly feels that this committee, as well as other Congressional committees handling authorization for NOAA, USGS, NSF, et cetera, may not be fully aware of the actual dollar amounts spent on hydrologic and water resources related studies. Because the Federal budget for water is scattered among various agencies, an accounting of how much actually goes for research, for development, demonstration, technology transfer, is very difficult.

Coming from an academic environment, I know that less than $10 million a year is spent extramurally for basic research in hydrology. This amount goes to both universities and consulting companies.

Much of this money comes through NSF and USGS grant programs. Both of those programs are somewhat endangered because NSF no longer has any program directly dealing with water resources and hydrology. The other program is the Federal Water Resources Research Act of 1984, P.L. 98-242, which provides for the USGS grant program. This was passed over presidential veto and has subsequently been funded at anything near the authorized level and it is coming up for re-authorization in 1989.

The National Weather Service's Office of Hydrology had an extramural research of about $500,000 a year in the late seventies, and that has almost gone to nothing at the present time.

All of these cuts really create a lot of concern on our part with respect to training of the new generation of hydrologists and water resources scientists that have to deal with the pressing issues that will come up in the future, and also our ability to do basic research that will be of help to agencies such as NOAA and others that deal with the management of water resources.

Now, with respect to how much money is spent within these agencies—USGS and NOAA, etc.—on water resources related problems, I do not have those figures. But looking at the records, a lot of cuts have been proposed this year, which really again causes some concern. For the record, I will mention a few things that at least have been proposed: a $1 million cut in the Federal data collection and analysis; $10.9 million cut in the national water information access program; $3 million cut in the national water quality assessment program; $2.3 million cut in the Federal-state cooperative programs for data collection and analysis; $2 million cut in regional aquifer systems analysis.

Cuts in the National Weather Services hydrology program of about $250,000 have been proposed every year, but fortunately, Congress has put these monies back into their budget.

Now, the issue here, of course, is the satellite and some of the other NOAA programs and their relation to hydrology. What we need is improved water resources forecasting tools for decision making. And this problem is not necessarily difficult, nor does it require large expenditures.

Now is the perfect time to capitalize on the existing and planned state-of-the-art computer network and processing and data gathering programs, such as the NEXRAD and AWIPS, some of these programs that have already been mentioned here.

With marginal additional investments, we can improve our basic understanding of the hydrologic processes and develop a state-of-the-art water resources forecasting technology, and also make complementary improvements in flood warning programs. The natural candidate to undertake these activities is the Office of Hydrology within NOAA. Among all agencies, NOAA has the clear mandate to provide real time forecasting of our nation's rivers and streams. The Office of Hydrology within the Weather Service has the resonsibility of dealing exclusively with hydrologic forecasting problems.

I know of the activities of the Weather Service's Office of Hydrology because of the cooperative agreements we have had over the past six or seven years, and in particular, our research group is involved with them to develop better forecasting models for their river forecast system. There is no question that the Office of Hydrology is the leader in science and technology in hydrologic forecasting, and I hope with more support it will stay what it is now. With more financial resources, they can initiate the research and development of the state-of-the-art forecasting models and integrate them with the NEXRAD and ASOS and the AWIPS technology improvements, which are already under way.

Our present river forecast models are not up to par with theoretical developments in the areas of mathematical modeling, computer techniques, and hydrometeorological data gathering and analysis methodologies. We must improve our short-term, mid-term, and long-term time scales for forecasting for a wide variety of water resources situations. The future models should be able to use real time measurements from multiple sources, both remotely sensed data as well as radar and ground truth gauge networks, many of which will become available with some of the programs that have already been discussed here.

In regard to flood forecasting, we need the capability of predicting and preventing disasters, rather than having to wait until after the damage is already done. In the case of the Colorado River in the '83 flood, there is no reason that the available information could not have been shared. We knew that fast melting snow water was going to come and having known ahead of time, they (reservoir operators) would have been able to operate their reservoirs better.

Now, to conclude my testimony, I wish to urge this committee to give serious consideration to the needs of the hydrologic community with respect to some of these programs. If I may use the analogy, with NEXRAD and ASOS programs, we will get better meteorological data that could serve as high grade fuel or high octane fuel for our forecast models.

The AWIPS will provide us the computational processing power that could serve as a powerful engine for the forecasting machine, and also its communication network could provide a nice way of communicating between different weather and river forecast centers.

In order to make the machine run efficiently, we need to design a carburetor and the tools necessary to tune the engine and also provide the necessary training to drive the machines. And that is where the hydrologic forecast program can play a role and why it should be initiated.

The nation will definitely benefit from all the programs already mentioned—the NEXRAD, AWIPS—but not to the extent it could if we do not have better water resources management forecasting tools in place. The development of the state-of-the-art water resources technology is not a difficult one. Speaking on behalf of the hydrologic community, I am convinced it is worth the relatively small investment.

Thank you for your attention.

[The statement follows:]

STATEMENT OF DR. SOROOSH SOROOSHIAN

Mr. Chairman and committee members, my name is Soroosh Sorooshian, and I am a Professor in the Department of Hydrology and Water Resources Administration at the University of Arizona in Tucson. I have been involved with teaching and research in the field of hydrology and water resources for over a decade. The purpose of my testimony is to inform this committee of the urgent need for improved hydrologic forecast services for this nation.

America's fresh-water resources are vital to the national economy and well-being. With the ever-growing demand, reliable supplies of fresh water are becoming increasingly scarce. "Structural" alternatives (i.e., construction of reservoirs, aqueducts, etc.) to keep pace with increasing demand are no longer the preferred solution to the problem. Even though continued sensible capital investment to augment existing supplies and to provide additional flood control protection is definitely part of the solution, "non-structural" approaches are now the key to securing reliable and cost-effective supplies. While record-breaking droughts and floods are serious and provide drama, local and regional water-management decisions are a necessary and daily fact of life in this country. Barge companies decide how heavily loaded each barge should be. Release schedules for hydropower generation and for low-flow augmentation for environmental and wildlife protection are determined. Farmers decide how much irrigation acreage to plant in what crop. Reservoirs are operated to balance flood protection against water conservation. Almost without exception, these decisions are based on information far less complete than can be provided, and if we do not improve the information and the handling of it now, there will be serious and undesirable consequences down the road.

Despite wide-spread recognition of the urgency for development of scientifically-based water resources management tools, federal support for basic and applied research has been declining for several years. The scientific community strongly feels that this committee, as well as other Congressional committees handling authorizations for NOAA, USGS, NSF and many other agencies, may not be fully aware of the actual dollar amount spent on hydrologic and water resources related-research. The Federal budget for water is scattered among the various departments and agencies, and attempts at a total inventory are subject to inconsistencies in the categorization of programs as "research" as opposed to "development", "demonstration", and "technology-transfer" by the reporting agencies. Much of this money supports the research programs within the agencies and the national laboratories, while a small percentage goes towards funding extramural research (universities, the private consulting sector, etc.). Estimates are that only less than $10 million per year is spent extramurally for basic hydrologic research and development. This includes all NSF and USGS grant programs, and this money supports projects dealing with all facets of hydrology (e.g., flood and drought studies, pollution studies related to both ground and surface waters, etc.). Unfortunately, the future of both USGS and NSF grant programs is uncertain, and the scientific community is extremely concerned. The Federal Water Resources Research Act of 1984 (PL. 98-242), which provides for the USGS grant program, was passed over a presidential veto and has subsequently been funded at anything near the authorized level. The original authorization was for five years and will be up for re-authorization in 1989. The recent reorganization of the NSF Engineering Directorate has practically eliminated the explicit recognition of hydrology. The ability of the NWS Office of Hydrology to support extramural research has steadily eroded from a budget of some $0.5 million in the late 1970's to essentially nothing today. In each of the previous three years, a $250,000 cut in the internal hydrologic research program of NWS has been proposed, but not accepted. The point is that the extramural support to universities must be increased. If not, our training of hydrologists to fulfill the needs of various federal, state, local agencies, and the private sector will be adversely affected. As a result of this, our ability to do basic research will be greatly hindered.

I have no information about the total dollar amount spent annually by various agencies internally on basic hydrologic research. Most probably, the amount is small and certainly shrinking. [Note: the administration's proposed budget for next fiscal year will result in a $1 million cut in Federal Data Collection and Analysis; a $10.9 million cut in the National Water Information Access Program; a $3 million cut in the National Water Quality Assessment Program; a $2.3 million cut in the Federal-State Cooperative Program for Data Collection and Analysis; a $2 million cut in Regional Aquifer Systems Analysis, and other cuts in hydrologic and water resources research.]

With respect to providing improved water resources forecasts for decision-making regarding the better management of our nation's water resources, no coordinated research and development effort has yet been initiated. This problem is not necessarily difficult nor does it require large expenditures. Now is the perfect time to capitalize on existing and planned state-of-the-art computer networking and processing and data gathering programs (e.g., NEXRAD, ASOP, AWIPS-90, etc.). With marginal additional investments, we can improve our basic understanding of the hydrologic processes, develop a state-of-the-art water resources forecasting technology, and make complementary improvements in the flood-warning program—the latter two of which will be available to many more communities across the nation with an enhanced degree of accuracy and longer lead time. The natural candidate to undertake this activity is the Office of Hydrology of NOAA. Among all agencies, NOAA has the clear mandate to provide real-time forecasting of America's rivers and streams. The Office of Hydrology within NWS has the responsibility of dealing exclusively with hydrologic problems. I know of the NWS hydrology program largely through my association with the Hydrologic Research Laboratory (HRL), which is the research arm of the NWS Office of Hydrology. Over the past eight years, I have been working closely with HRL through a cooperative research agreement on the development and implementation of advanced calibration for their river flow forecast models. There is no question that NWS is the leader in science and technology for hydrologic forecasting. Therefore, NWS is in an excellent position to provide the leadership in the development of improved water resources forecasting technology. With additional financial resources, they can start to initiate the research and development of state-of-the-art forecasting models that will integrate well with the NEXRAD, ASOP, and AWIPS-90 technological improvements which are already underway.

We must start now if we are to respond to the water management needs of the 1990's and beyond. Our present river forecast models are not up to par with theoretical developments in the areas of mathematical modeling, computational techniques, and hydrometeorological data gathering and analysis methodologies. We must improve our models to be capable of satisfying forecast needs at near-, medium- and long-term time scales for a wide variety of water use situations nationwide. The future models should be able to use real-time measurements from multiple sources, both remotely-sensed data as well as radar and ground-truth gage network, many of which will become available as a result of the new NOAA programs. Current forecast techniques make little or no use of growing NOAA skill in medium- to long-range weather and climatic forecasts. Improved calibration techniques must be implemented in order to enhance the accuracy of the model forecasts. In addition, we need to better understand the dynamics of precipitation at the river basin scale in ways that will allow operational parameterizations that facilitate improved flood warning. In regard to flood forecasting, we need the capability of predicting and preventing disasters, rather than having to wait until after the damage is already done (e.g., the floods of 1983 in lower Colorado). We must develop the appropriate techniques to provide water managers and emergency planners with critical information on forecast reliability. Their decisions will be made based on the forecast information provided to them by NWS and, therefore, they must be aware of the reliability of that information. In addition, these services should and will be provided to a growing private sector vendor community that will cater to the needs of specific industries. These companies will see a new opportunity to tailor the forecast information products to serve irrigation companies, industrial sites, along nation's waterways, riverine navigation companies, and many others. The above examples were only a few of the critical and emerging research areas that must be dealt with if we are to have a viable water resources forecasting technology. My colleague, Professor Rafael Bras of MIT, in his written testimony, has presented additional problem areas needing immediate attention.

To conclude my testimony, I urge your committee to give serious consideration to their proposed initiatives for improved management of water resources and hydrometeorologic forecasting. With NEXRAD and ASOP programs, we will get better meteorologic data that could serve as high-grade fuel for our forecast models. The AWIPS-90 will provide us the computational processing power that could serve as a powerful engine for the forecasting machine. In order to make the machine run efficiently, we need to design the carburetor and the tools necessary to tune the engine and also provide the necessary training to the drivers and mechanics responsible for its operation and maintenance. Congress has already provided for the data gathering and processing programs that will be at the frontiers of science for decades to come. The nation will definitely benefit from this new technology, but not nearly at the level it should as long as we continue using outdated water resources forecasting, management, and planning techniques. The development of a state-of-the-art water resources forecasting technology with the required educational programs will provide us this missing link. Speaking on behalf of the hydrologic scientific community, I am convinced it is worth the relatively small additional investment.

I thank you for your attention.

[The following information was subsequently received for the record:]

Questions of Senator Kerry and the Answers

Question. Can you estimate an annual dollar figure for such investments?

Answer. $8–10 million/year.

Question. What is the difference between current hydrologic forecasting techniques and the skills employed in weather and climatic forecasting?

Answer. In relation to the NOAA's mandate hydrologic forecasting deals with the estimation of river flows. The techniques and models employed to accomplish this objective (hydrologic forecasting) use precipitation measurements and convert them to flow estimates.

Current skills employed in weather and climatic forecasting by NOAA, on the other hand, deal with accurate estimation of meteorological information (e.g., precipitation measurement, etc.) over a given watershed, both in time and space. This information will serve as fuel for hydrologic forecasting models.

Question. How should these other skills be applied to hydrologic forecasting?

Answer. With the new initiatives (NEXRAD, AWIPS–90, etc.), we will have more accurate meteorological information at a very fine scale. We must start the development of an appropriate hydrologic forecasting model which can process this information and provide planners with more reliable river flow forecasts with various lead times.

Question. Please explain what happened in the 1983 flood.

Answer. There was a late season snow storm over the Colorado Rockies. This storm was followed by a sudden warming of the weather which resulted in unusually rapid melting. This weather combination, along with untimely availability of information on the rate of melt, did not give the planner enough lead time to release water from the various reservoirs on the Colorado in order to make room for the additional waters. As a result, flooding in the lower Colorado river was unavoidable.

Question. What steps would prevent a recurrence of such inadequate flood forecasting?

Answer. First, we would have benefitted from additional information such as more frequent satellite pictures showing the rate at which the snow line was changing. Second, we could have benefitted through implementation of recently developed techniques such as the Extended Streamflow Prediction (ESP). With techniques such as ESP, one can forecast the full probabilistic range of flows into the future and evaluate various operating scenarios. Third, we must continue our basic research into the development of distributed, stochastic rainfall-runoff models.

Question. Have recent NOAA appropriations for Colorado River basin hydrology accomplished the needed results?

Answer. Definitely yes.

Question. What is the advantage of a national hydrology initiative over initiatives like these that are targeted at particular floodprone areas?

Answer. Initiatives like the Colorado River basin, Susquehanna River basin, etc. have been very useful in the sense that we have learned a lot from them. Such initiatives have shown that application of some recent techniques in the field of flood forecasting can be very helpful to minimize losses due to floods. However, techniques developed and implemented for the river basins mentioned in this question are custom-made and specific to these regions. They are also specific to a single objective: flood prediction and prevention. If another river basin experiences problems such as those mentioned, we will not have the capability of dealing with them and therefore must start another initiative to deal with its problem which will usually be late and expensive. The advantage in a national water resources management forecast initiative is that it will provide a system applicable to all river basins and, in addition to flood forecasting, will provide answers to questions that are asked daily by water resources managers, irrigation districts, hydropower companies, barge companies, etc.

Senator KERRY. Thank you very much, doctor.

Dr. Fleagle.

If I could ask, I am going to ask the light work here so we can just get an indicator. You do not have to be absolutely strict, but you get a sense where we are. Thanks.

Dr. Fleagle.

Dr. FLEAGLE. Senator Kerry, I am Robert Fleagle, Professor of Atmospheric Sciences at the University of Washington in Seattle. I have brought with me a written statement which your staff has, and I would like to summarize and comment on some of the points of that statement.

Senator KERRY. Let me just say, doctor, as you go on, for all of you, your full written statements will be made part of the record.

Dr. FLEAGLE. A general defense of NOAA's program is not needed here, for it has been this committee under both Republican and Democratic leadership which has preserved NOAA over the last six years. Without the committee's efforts, the weather satellites and parts of the Weather Service might well have been stripped from NOAA, research would have been eviscerated, there would be no Great Lakes laboratory, no Sea Grant, and little would be left of the Fisheries Service.

NOAA can be regarded as the flagship of the national effort to observe and understand the ocean and the atmosphere. But the flagship has taken shots through the rigging and a few shots have hit perilously close to the water line. The officers and crew have had to concentrate their attention on keeping the ship upright and afloat.

NOAA's most basic responsibility is to observe the atmosphere and ocean, and weather satellites are essential to this mission. Costs of weather satellites have increased greatly over the years. These costs now constitute about one-third of the total NOAA budget. Nevertheless, operational satellites are using outmoded technology and the new proven technologies are not in use.

NASA no longer supports development of operational weather satellites, and NOAA's budget has never permitted more than a token minimal development effort. The 1990's will bring a requirement for more accurate, more powerful observations than are now possible, and a program of satellite development commensurate with those requirements is vitally needed.

With regard to handling of satellite data, NOAA and NASA have been keenly aware of a serious and increasing problem. New, more sophisticated global observations expected in the 1990's will enormously increase the challenge to NOAA data handling capabilities.

Already, valuable data sets have been lost due to inadequate resources to process and archive them. Without strengthened capability to take advantage of the expected increase in data flow, it will not be possible to use the data with full efficiency for research or for operations and services. In this event, we would choke on the flood of data, and a national asset of incalculable value would be lost.

I would like to turn next to observations and research concerned with atmospheric chemistry and air quality, that is to programs concerned with acid precipitation, effects of carbon dioxide and other gases on world climate, the effects of radioactivity released from nuclear power plants or from nuclear explosions, and the global consequences of nuclear war.

Although NOAA scientists are in the forefront of research fundamental to these problems, NOAA has not been able to exert the needed leadership due to restricted budgets. For example, the Acid Precipitation Act of 1980 established the National Acid Precipitation Assessment Program (NAPAP) and designated NOAA and EPA as lead agencies.

With Administration encouragement, the total inter-agency budget for NAPAP is now more than $80 million per year. Nevertheless, OMB has held NOAA's part of the budget to less than five percent of the total, too little to permit NOAA to exert leadership.

Another example concerns the effects of changes in the concentration of CO-2, freons, methane, and other trace gases. The National Academy plan identifies NOAA, NASA, and NSF as lead agencies and calls for increases for the three agencies from about $25 million this year to about $90 million in fiscal year 1993.

NASA and NSF appear to be in step with this plan, but NOAA has not been able to fund its part at the projected level.

It is important also that this committee recognize that policy implications relating to air quality are largely invisible at policy levels of the major agencies. Therefore, implications of research results for international relations or for use of natural resources or national defense can be easily overlooked by the agencies most responsible for these matters.

This situation might be much improved by assignment to NOAA of major responsibility for air quality research.

NOAA's role in Arctic research presents an issue which I should like to call to the attention of this committee and which has been inadvertently omitted from my written testimony. NOAA operates fleets of ships, aircraft, and satellites dedicated to environmental observation, and it does conduct some Arctic research.

However, it has no leadership role in planning or management of these programs. Specialized national Arctic research institutes operate in virtually every nation with interest in the Arctic, with the exception of the U.S. As a consequence, our Arctic research is typically short term and fragmented, and continuity of observations cannot be assured.

The Arctic Research and Policy Act of 1984 did provide for an inter-agency committee, but this step is far too little. A national plan is needed for the foundation for policy actions by the Congress that would place Arctic research in this country on a basis comparable to that in other countries.

To summarize my views on the NOAA budget which is before you, I urge you to view it with perspective extending into the 1990's and beyond. This budget supports the agency which, as I described it earlier, is needed as the flagship of the nation's efforts to understand the natural environment.

It is not now performing that role adequately, and several years may well be required to enable it to do so. I urge you to start this process by strengthening the research and service activities that are needed now, but also are addressed to long term objectives.

This will help to provide the foundation for the creation of an independent NOAA, an action which I hope this committee will consider in the future.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF ROBERT G. FLEAGLE

Mr. Chairman and members of the committee, I am Robert G. Fleagle, Professor of Atmospheric Sciences at the University of Washington in Seattle. In addition to teaching and doing research at the University of Washington, I have served in a variety of administrative and advisory capacities at the University, the Office of Science and Technology, the National Academy of Sciences, the University Corporation for Atmospheric Research, and other scientific and professional bodies. Much of my scientific work has been concerned with interaction of the atmosphere and ocean, and this has brought me into continuing contact with NOAA programs and NOAA scientists and officials. I also have been interested in science policy; in this connection I have studied NOAA's history, its wide-ranging responsibilities for observing and understanding the atmosphere and ocean, some of the problems it has encountered, and changes needed to provide the capabilities to meet its challenges more fully.

I am glad to be here this morning to discuss with you aspects of the NOAA budget for FY 1988, especially the research budget and its relation to NOAA services and more broadly to national needs. I will begin by noting that NOAA scientists and professionals play critical roles in the national effort to understand the ocean and atmosphere and to respond wisely to changes in the natural environment on all time scales. NOAA can be regarded as the flagship of the national effort to understand the ocean and atmosphere. To a considerable degree NOAA carries the brains, the memory, the instrumentation and communications, and the technical skills upon which we must rely to respond to environmental changes and to use and protect our environmental resources.

But the flagship has taken shots through the rigging, and a few shots have hit perilously close to the water line. The officers and crew have had to concentrate their attention on keeping the ship upright and afloat. We cannot look to another federal agency to take over the flagship role, and I think we must somehow get NOAA out of the line of fire and strengthen her to carry forward the many vital tasks the agency is charged with.

Although the future is largely unknown, there can be little doubt that all possible efforts will be required to increase global food production, to develop water resources, to understand acid precipitation, to limit air and water pollution, to monitor a growing array of global changes affecting agriculture and health, to anticipate the effects of the increasing carbon dioxide content of the atmosphere, to anticipate the effects of man-produced gases on the stratospheric ozone shield, and to reduce loss of life from hurricanes, tornadoes and floods. The nation is not well equipped to meet these demands.

These remarks have not addressed budget issues directly, but I believe they are needed as background if we are to understand the importance of the NOAA budget or of its components. For each of the past six years the President's budgets have called for reductions in NOAA funding averaging about 15% in current dollars. This committee has opposed the proposed cuts, and its efforts together with corresponding efforts in the House have preservd most on-going programs. However, NOAA's appropriations have increased at a rate less than inflation; the total NOAA budget was $1001 million in FY 1983 and $1090 million (estimated) in 1987. At the same time costs of the weather satellite program have increased dramatically. In the early 1970's the cost of purchasing and launching a NOAA satellite was about $30 million. It is now about $125 million, more than 10% of the total annual NOAA budget. In FY 1985 $258 million was used for purchase of satellites, launching, and services, 25% of the total NOAA budget. This does not mean that too much has been spent on satellites or that important NOAA programs should be salvaged by budget transfers from satellite funds. In fact, the satellite program has been on a diet of malnutrition for some time. The point is that the over-all budgets do not provide an accurate picture of the lost opportunities and limited capabilities under which NOAA labors.

I'd like now to address some of the specific elements of the budget. NOAA's most basic responsibility is to observe the atmosphere and ocean, and weather satellites are essential to this mission. The operational satellite program has been based on a 1963 interagency agreement under which NASA was responsible for development of satellites of increasing capabilities while NOAA was responsible for operations. However, NASA funding for weather satellite development decreased in the late 1970's and ended in 1979. Although NOAA has conducted a small program of satellite R and D, it has not been able to fill the gap. As a consequence, operational NOAA satellites are using outmoded technologies; and new proven technologies, such as those for securing wind velocities over the ocean and stratospheric temperatures determined from limb scanning, are not in current use in operational satellites. The 1990's will bring requirements for more accurate and powerful observations than are now possible, and we should be moving vigorously to develop them.

Let me turn next to the use of satellite data and to NOAA's responsibility for its processing, archiving, and dissemination. NOAA and NASA have been keenly aware of the difficulty of coping with the ever-increasing flood of raw data pouring down from satellites into computers and data banks. NOAA has created the National Environmental Satellite, Data, and Information Service (NESDIS) to deal with this flood. The new attention which must now be directed at more sophisticated global observations enormously increases the difficulties facing us in the next few years. Already, valuable data sets have been lost due to inadequate resources to process and archive them. I understand that several years of vertical sounding data from the NOAA polar orbiter, data necessary to provide an extended base of polar data, cannot be economically accessed by NESDIS. In this case the data have been transferred to the National Center for Atmospheric Research (NCAR), supported by the National Science Foundation, so are not irretrievably lost; but access depends on resources which we must hope that NCAR can provide. This example illustrates both the strengths and the weaknesses of the present situation; NOAA and NCAR, faced with the loss of valuable data, have put together a plan which salvages the data at least for now. This kind of cooperation is common among environmental science institutions within the federal government and outside - thank God it is. But this example also exposes NOAA's limited capabilities for keeping up with the current data stream. NOAA should be gearing up both to secure global observations and to manage the data efficiently. Without strengthened capability to manage the data it will not be possible to use the data efficiently for research or for operations and services. In this event we would choke on the flood of data, and a national asset of incalculable value would be wasted.

I turn next to observations and research concerned with atmospheric chemistry and air quality. The significance of this work ranges from the obvious - air pollution - to the subtle - depletion of the earth's ozone shield. Included are programs concerned with acid precipitation, effects of CO_2 and other gases on world climate, and effects of radioactivity released from nuclear power plants or from nuclear explosions. These programs are highly relevant also to investigations of the global consequences of nuclear war. NOAA scientists are in the forefront of research being conducted on these critical problems. But restricted budgets have not permitted NOAA to exert the needed leadership in interagency research programs. For example, the Acid Precipitation Act of 1980 established the National Acid Precipitation Assessment Program (NAPAP) and designated NOAA and EPA as lead agencies. Although this interagency program now has an annual budget over $80 million, NOAA's part of this is less than 5%, too little to permit NOAA to exert the needed leadership. Another example concerns the interagency effort to understand and predict the consequences of changes in trace gas constituents of the global atmosphere. The National Academy of Sciences plan for this program identifies NOAA, NASA, and NSF as lead agencies and calls for increases from the FY 1986 level of about $25 million for the three agencies to about $90 million in FY 1993. Whereas NASA and NSF appear to be in step with this plan, NOAA has not been able to fund its part at the projected level. Another related matter of which the Congress should be aware, is that although air quality problems may have very important policy implications on the national and international level, these implications seldom receive appropriate attention at policy levels. Interagency programs are largely invisible at policy levels of the Departments of State, Interior, and Defense; and implications for international relations, use of national resources, conservation, and national defense therefore can be easily overlooked. The situation could be much improved by assignment to NOAA of major responsibility for air quality research.

NOAA has provided much of the leadership in the research which has led to recognition of the linkages between ocean temperatures in the tropical Pacific and weather over North America and other parts of the world. These achievements have stimulated scientists all over the world to pursue new lines of investigation. Research on ocean atmosphere interaction is clearly in a period of excitement and rich productivity; it has provided real encouragement to efforts to understand and predict changes in climate. NOAA funding for the Tropical Oceans and Global Atmosphere Program (TOGA) which was 5.5 million in FY 1986, is reduced in the Presidents budget to $2.5 million. It is urgent that this be restored. Many other examples could be cited to demonstrate that important ongoing research justifies substantial increases in NOAA's research budget.

NOAA's role in Arctic research exposes an important defect in U.S. policy which I should like to call to the attention of this committee. No U.S. agency has had responsibility for Arctic field research or its management. Whereas specialized national Arctic research institutes operate in Canada, Norway, Sweden, Denmark, W. Germany, Iceland, Japan, the United Kingdom, and the

U.S.S.R., there is no similar institute in the U.S. Our Arctic research is therefore typically short-term and fragmented, and continuity of observations cannot be assured. NOAA operates fleets of ships, aircraft, and satellites dedicated to environmental observation; and the agency does conduct Arctic Research programs, and contributes to the research of other agencies. However, it has no leadership role in planning or management of international polar programs. A committee of the National Research Council has reviewed the needs for data in Alaska's ocean areas and has assessed NOAA's capabilities for meeting these needs. The Congress, through the Arctic Research and Policy Act of 1984, created the Interagency Arctic Research Policy Committee to provide coordination and coherence, and the committee has issued a draft report consisting of five research plans to be carried out by the agencies involved in Arctic research. Although these are steps in the right direction, they are far too little. A national plan is needed as the foundation for policy actions by the Congress and the Executive Branch which would place Arctic research in this country on a basis comparable to that in other countries with interests in the Arctic.

These examples illustrate the fact that the objectives of NOAA research and services support the missions of other government agencies concerned with the natural environment. The National Climate Program and National Acid Precipitation Assessment Program (NAPAP) are examples of programs established by Congress as interagency programs. Others, such as the Tropical Oceans and Global Atmosphere Program (TOGA), have been established by the agencies themselves and their working scientists. Comparisons of recent R and D budgets for FY 1986, 1987, and 1988 for some of these agencies provide another perspective on the NOAA budgets.

Table 1 lists NOAA's Operations, Research, and Facilities (ORF) budgets (essentially the total NOAA budget) and separates out the part applied to Oceanic and Atmospheric Research (OAR). Also shown are the NASA Space Science and Applications (SSA) budgets, the EPA R and D budgets, the NSF Atmospheric, Ocean, and Arctic research budgets, and the DOD R and D budgets.

Table 1: Annual Budgets ($ millions)*

	FY 1986 (actual)	FY 1987 (est.)	FY 1988 (prop.)	Two Year Change
NOAA ORF	1141	1197	1091	-13%
(OAR)	(134)	(145)	(82)	(-39%)
NASA SSA	1477	1527	1508	+ 3%
EPA R and D	317	329	346	+ 9%
NSF Atm. Ocean, Arctic	220	235	267	+21%
DOD R and D	34,205	37,533	44,080	+29%

This table shows clearly that NOAA has been treated much more harshly by OMB than other agencies responsible for related missions. The reduction proposed for Oceanic and Atmospheric research ($63 million) will be enormously destructive if it is implemented. Even if the proposed reductions are reversed by Congress, the energy, time, and morale consumed in dealing with the proposed budget will be a permanent loss to the agency and the nation.

To summarize my views on the NOAA budget which is before you, I urge you to view it with perspective extending into the 90's and beyond. This budget supports the agency which, as I described it earlier, is needed as the flagship of the nation's efforts to understand the natural environment and to conserve and use natural resources wisely. It is not now performing that role adequately, and several years may well be required to enable it to do so. I urge you to start this process by strengthening research and service activities that are needed now but also are addressed to long-term objectives.

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* Adapted from EOS, American Geophysical Union, Feb. 10, 1987.

RESPONSES TO QUESTIONS SUBMITTED BY SENATOR JOHN KERRY SENATE COMMERCE COMMITTEE HEARING, MAY 19, 1987 ON NOAA ATMOSPHERIC/SATELLITE PROGRAMS

Robert G. Fleagle
University of Washington

1. Several scientific groups have recently proposed comprehensive research initiatives to assess human effects on the earth system and to increase our understanding of global environmental processes.

-- **Which agencies should be involved in such an initiative? What is the appropriate role for NOAA?**

Answer: The U.S. Agencies whose missions justify primary roles in research on global environmental processes are NOAA, NSF and NASA. More limited roles should be played by DOE, EPA and USGS, and DOD. Other agencies having somewhat less direct interests in global environmental research include State, CIA, DOT (FAA and Coast Guard), DOA, HHS and Bu Rec. NOAA as presently staffed and structured has special competence and responsibilities in atmospheric and oceanic observations and research and, through existing legislation and directives, certain responsibilities for interagency leadership and coordination. However, I believe there remains an unfilled need for effective leadership and coordination which should be filled by NOAA.

-- **How would the present NOAA programs such as Tropical Ocean Global Atmosphere (TOGA), Radiatively Important Trace Species (RITS) and Geophysical Monitoring for Climate Change (GMCC) contribute to a global research initiative? Do you feel that these programs are adequately funded at the present time?**

Answer: Each of the programs cited is based on common perceptions of the need to increase understanding of global environmental processes. Results can be expected to contribute to the broader goal of understanding global interactions of the atmosphere, ocean, earth, and biosphere. Funding levels for FY1986 and FY1987 have been adequate to carry forward important, though limited, efforts within TOGA, RITS and GMCC. However, it is important to strengthen the linkages and interactions between them. For example, RITS has emphasized trace gas observations and processes in the atmosphere while TOGA has concentrated on observations in ocean regions. GMCC has concentrated on atmospheric observations, but the fullest interpretations of the observations probably will require understanding of processes in the ocean and at the ocean-atmosphere interface. These steps fully justify the $5.5M proposed for TOGA and the $5.5M proposed for RITS. To reduce either or both to $2.5M, as the President's budget does, would perilously weaken the program and would undermine NOAA's capacity for interagency leadership.

-- **Can you make suggestions for related research which would fall within NOAA's expertise and contribute to our understanding of global climate change?**

Answer: A stronger NOAA program of Arctic research would contribute substantially to understanding of global climate change. Three elements are needed: 1) a program of long-term observations utilizing buoys, ships, aircrafts and satellites, 2) an institute or laboratory capable of the logistics required for a variety of on-going research activities and for marshalling the efforts of scientists from other agencies and universities, and 3) assignment to a single agency of central responsibility for leadership in international research programs.

2. **Satellite observations appear to enjoy widespread scientific appreciation for their contribution towards understanding global processes. I understand that these satellites generate millions of observations.**

-- **Do you feel that our current system of data management is adequate to make full use of the satellite data available? Could you offer any suggestions for improving data management?**

Answer: Responsibility for satellite data management, formerly shared by NASA and NOAA, has been abandoned by NASA, and NOAA has not been able to shoulder the increased burden. At the same time data flow has increased, with the result that NOAA-NESDIS budgets have been effectively overwhelmed. Current plans for global environmental research will greatly increase the need for data management capabilities in the 1990s far beyond that provided in present or future budgets. For example, present demand for high resolution radiation data has outstripped the capacities of NOAA staff and resources. As a result, NCAR is considering establishment of a data distribution center. But this appears to be a specific, short-term response to a general, long-term and larger problem. NCAR cannot replace NESDIS. As another example, passive microwave data in polar regions can be of great value in understanding changes in ice cover and its role in global climate. Extensive files of these data exist, but due to lack of resources and a clear line of responsibility, have not been analyzed and interpreted. Better data management will require larger funding, either by NOAA or by NASA, and recognition of the dimensions of the task at all levels. When NASA withdrew its support for satellite data management, assurance should have been provided at the OMB level that NOAA resources would be increased to meet the new demand.

-- **Have you found that data needed from NOAA was readily available in an easily used form?**

Answer: At present NOAA is not able to provide efficient service to users of satellite data, and the cost of data is high. Researchers who require the data are generally critical and dissatisfied with the level of service.

-- **Please describe how satellite observations are verified and calibrated. Do you feel that any changes are needed in this area?**

Answer: Calibration of satellite sensors and verification of data are, of course, highly technical subjects. Sensors are calibrated in the laboratory, but in most cases corrections are necessary for conditions in orbit. Calibrations also are carried out in orbit to account for changes in sensor characteristics occurring over time. Verifications of data are carried out in a variety of ways: output from sensors on a single satellite or on various satellites are compared, and remotely sensed satellite data are compared with directly sensed measurements made on the earth's surface or in the atmosphere.

As satellite technology has advanced funds have gone into development of satellites and sensors, but inadequate attention has been directed at verification and calibration. As a result, trends cannot be determined reliably from most satellite data. Since determination of trends is critical to much of climate research, major improvements are needed in this area. As another example, inadequate planning and support has been available for "ground-truth" comparisons of satellite data and surface or atmosphere measurements.

3. Are you familiar with the current concern over the effect of chlorofluorocarbons on atmospheric ozone? Based on your understanding of the scientific data, what policy recommendations would you make with respect to regulating international and domestic CFC production?

-- **Answer**: I have followed developments concerning the ozone problem from both the scientific and policy perspectives, although I have not been a participant in the research. I believe that potentially serious global consequences may result from changes in chlorofluorocarbon and other trace gas concentrations. This possibility justifies prudent actions to reduce world-wide production of these gases and development of benign substitutes. Equally important, we should institute careful studies of policy options and their consequences, and these studies should be started as soon as possible. Serious policy decisions may be required within the next decade.

However, major uncertainties remain as to atmospheric processes affecting chlorofluorocarbons. I believe that we don't know enough to introduce arbitrary regulations or to press for tight international control at this time.

4. You mention in your testimony that interagency air quality programs "are largely invisible at policy levels of the Departments of State, Interior, and Defense."

-- **Given NOAA's difficulty maintaining visibility even within its own Department of Commerce, why do you contend that**

increased policy attention would result from assigning NOAA major responsibility for air quality research?

Answer: The national program of air quality research is lacking in coherence and leadership, is focused on limited goals, and is fragmented among agencies. No single agency is equipped to communicate air quality policy implications to appropriate levels where policy is developed. I do not advocate simply adding air quality to NOAA's full plate; other changes are needed to make NOAA's role properly effective.

NOAA's current capabilities should be utilized much more effectively than they are. Assignment of major responsibility for air quality research to NOAA should improve the quality of research and our understanding of a range of important problems relating to air pollution, acid precipitation, ozone, carbon dioxide and transport of radioactive particles. Improved understanding would attract greater interest of the public and would justify greater attention at policy levels of government.

It is important, also to emphasize that these positive results would be more certain and greater of NOAA were constituted as an independent agency under a Congressionally mandated charter.

-- **What do you believe NOAA should be doing in air quality research that it is not now doing? What would be your rough estimate of the annual budget increase that would be needed to carry out such an enhanced role?**

Answer: NOAA is now engaged at a low level of funding in research on a wide range of air quality problems, and some of this research is of very high quality and importance. If NOAA were assigned major responsibility for air quality research, existing programs would provide a base for expansion. Also, NOAA would be enabled to exert stronger leadership in interagency programs. As one example, NOAA's share of the National Acid Precipitation Assessment Program amounts to less than 5% of the total interagency program, too little to exert leadership or to apply the observational and data resources of the agency to the acid precipitation problem.

There is not an adequate budget tabulation to provide an estimate of the funds required for NOAA to carry out an enhanced role. However, I would guess that about $50M, together with Congressional assignment of expanded interagency responsibility, would make a very great impact. This increase might well be off-set in other agencies through increased efficiency in inter-agency programs.

Senator **Kerry**. Thank you very much, Dr. Fleagle.

Dr. Emanuel.

Dr. **Emanuel**. Thank you, Mr. Chairman. I appreciate the opportunity to be here today to express some of my views.

You have my written report in front of you in which I summarize what I regard as each of NOAA's major responsibilities on the atmospheric side of what it does, and I agree with my colleagues that those major responsibilities are the collection and dissemination of meteorological data, severe weather warnings, and something that has not been mentioned so far here today, operational numerical weather prediction, and research in support of those objectives.

I would like to preface my remarks by saying that overall I believe NOAA does a truly outstanding job in each of these areas. But in view of the time I am going to focus on my criticisms of their performance in some of these areas.

A lot has been said here today already about satellite data and its various uses. This is, of course, only one form of data that NOAA collects. In my view, satellite data is important for two different reasons. First of all, operationally it is more or less important in proportion to the absence of other forms of data. For example, over the oceans, particularly in the southern hemisphere, satellite data is virtually our only operational data set that we use in making day-to-day weather forecasts and, of course, warnings.

But the other and perhaps more important function of satellites in general is as an investment in the future. While today I do not believe they provide exactly the kinds of data that we absolutely need to make warnings, except in the case of certain types of storms which I mention in my report, I think in the very near future new instrument systems will have been developed which really do allow satellite-based platforms to do the job that direct measurements are doing most of today.

But I do think there has been a neglect of conventional data sources, and I do not quite agree with some of the statements made by the NOAA management about the near-term availability of technological fixes or replacements for these conventional but unromantic sources of data. For example, the wind profilers are just that. They take measurements of wind in the atmosphere.

In their present stage they do not adequately measure wind close to the ground and in the foreseeable future there will be no means of accurately measuring temperature and water vapor profiles in the atmosphere, which are absolutely essential for operational weather prediction and for severe weather forecasting. And I do think that NOAA should pay more close attention to upgrading some of their conventional sources of data. Other than that, I have outlined my reasons in more detail in the report.

The second issue along these lines I want to address is the distribution of data. Up until now, it has not been entirely easy for organizations outside of NOAA to get raw meteorological data. In recent years NOAA has taken some very good steps toward fixing this problem and the concept of NOAA PORT is something that may in fact provide a real fix for this problem, allowing outside users access to the data.

And this is very important for several reasons. First of all, much of the actual forecasting that is done from day to day is done by the private sector. In places where they operate on the routine forecasting level, they do so very effectively. They must have continued access—it is in the public interest, I feel—to raw meteorological data. NOAA PORT or whatever system NOAA develops should allow access to raw as opposed to just tailored meteorological data. This access is also absolutely critical for meteorological research that goes on within and outside of NOAA.

Now, the other issue I think I am going to touch on briefly while I still have some time is operational numerical weather prediction, since we really have not talked about that yet today. This is, I think, one of NOAA's major responsibilities simply because it is a task far too large for anyone else to tackle. They do so very well, although there is the feeling among some of my colleagues that the Europeans have perhaps outdistanced us a little in this regard.

And I think this might be for two reasons. First of all, historically I believe certain segments of NOAA pertinent to this task have been underfunded. I am not in a position to say whether that is true today and many steps have been taken in recent years to fix this problem. For example, now finally the National Meteorological Center, NMC, has some fairly high-powered computers that can be used in the job of operational numerical weather prediction. But we were quite late in getting those.

The other problem I see that is partially related to the problem of an inadequate budget, is lack of interaction with outside researchers. The present director of the National Meteorological Center, Dr. William Bonner, has taken some effective steps toward correcting this problem, but he needs support and I hope he gets it.

I have focused necessarily on the criticisms, but I do not wish that to be taken as an overall criticism of the agency. I think generally we have a great deal to be proud of in NOAA. It does an excellent job.

[The statement follows:]

STATEMENT OF DR. KERRY A. EMANUEL, MASSACHUSETTS INSTITUTION OF TECHNOLOGY

Mr. Chairman and Members of the Committee, I am an associate professor of meteorology at the MIT Center for Meteorology and Physical Oceanography and have been engaged in research and teaching in meteorology for nine years. My areas of specialization include tropical and mesoscale meteorology, and among other duties I serve on the National Academy of Sciences Panel on Mesoscale Research which is especially concerned with the STORM program.

This testimony is divided into five sections dealing with what I view as NOAA's principle responsibilities on the atmospheric side of its organization. These include the collection and dissemination of meteorology data, severe weather watches and warnings, operational numerical weather prediction, and research in support of these activities. In my view, these responsibilities are essential to national interests and, for the most part, cannot at the present time be effectively carried out by components of the private sector.

1. COLLECTION AND DISSEMINATION OF METEOROLOGY DATA

At the time of its inception, the U.S. Weather Bureau was principally concerned with providing weather warnings for shipping on the Great Lakes. In support of this function it was necessary to make measurements of the atmosphere and to collect those measurements in one place. All modern weather forecasts, including severe weather warnings, are crucially dependent on observations of the atmosphere and since its inception it has been NOAA's responsibility to make these observations with U.S. borders and to collect data taken routinely all around the world. The magnitude of this task is too large to be undertaken by smaller organizations.

The means of making meteorology measurements may be divided into three categories: In situ measurements, ground-based remote sensing and satellite-borne remote sensing. While the popular perception is that modern weather forecasts rely heavily on satellite-based measurements, weather forecasts in the U.S. are far more strongly dependent on direct measurements made with instruments on the ground, buoys, ships, aircraft and balloons. Until very recently, these important data sources have been somewhat neglected by NOAA; for example, the number of radiosonde stations and the number of ship reports have been in steady decline over the past two decades. The U.S. government formerly maintained special weather ships in the Atlantic and Pacific and since these took radiosonde (balloon) measurements through the depth of the atmosphere they provided an important source of data that no longer exists. All of these in situ measurements provide sources of hard data (temperature, pressure, wind, etc.) that are necessary to make quantitative weather forecasts (see Section 4). In contrast, present satellite observations are for the most part qualitative; that is, they consist mostly of photographs of cloud cover. These are quite useful for very short term forecasts of thunderstorms and other small-scale weather events, and they are absolutely essential for detecting and tracking hurricanes, which spend most of their lives in regions otherwise devoid of data. Moreover, infrared radiometers provide some relatively crude temperature measurements and rough estimates of wind are made by tracking individual clouds. The last two forms of measurement constitute virtually the sole source of data over much of the world, especially the southern hemisphere.

The current investment in satellite observations is very large. Part of this is an investment in the future, since it will eventually be possible to make quantitative measurements from space using active sensing techniques (e.g., Doppler laser wind measurement). There is no doubt that the present array of polar orbiting and geostationary satellites serves an essential function as well as representing important steps toward the future, but it is far too early to abandon conventional means of measurement.

Recently, NOAA has taken a few steps toward correcting deficiencies in direct measurement techniques. The National Data Buoy Program provides surface measurements offshore and is a useful supplement to ships of opportunity, which appear to be reporting less frequently in recent years. Currently, NOAA is undertaking several programs to upgrade its conventional surface and upper air radiosonde measurement systems, which today exist in largely the same form as they did at the end of the second world war. From my perspective, some of these programs appear to duplicate high quality systems developed outside of NOAA. For example, the National Center for Atmospheric Research (NCAR), funded by the National Science Foundation, developed a sophisticated balloon-borne measurement system which can be operated by a single person and could conceivably be fully automated. This represents a major advance in direct measurement technology and has been successfully field tested. To my knowledge, NOAA has not moved to adapt this technology to its purposes. This is one area in which NOAA suffers from insufficient interaction with other agencies and individuals.

Meteorological data collected by NOAA and other non-military agencies are, of course, in the public domain. In the past, the real-time use of this data was confined mostly to federal agencies and university atmospheric science departments, the latter of whom often obtained the data by tapping into local National Weather Service data lines from Washington, D.C. The last 15 years or so have, however, witnessed a spectacular increase in the use of this data by private concerns who often act in the public interest. For example, television stations in major cities hire their own forecasters who use the data to issue public forecasts. NOAA has responded to the increased demand for data by providing a number of data circuits that outside users may tap into at the cost of dedicated telephone lines to Washington. (In the interim, the data circuits that serve the National Weather Service Forecast Offices have been configured in a way that makes them inaccessible to outside users.) Unfortunately, the costs involved in obtaining this data are prohibitive for smaller organizations. University departments, for example, must today contract with private firms that re-transmit data via satellite, often at substantial cost. As the smaller organizations often provide services useful to the public and since the research and education provided by universities is in the public interest, NOAA would be well advised to provide cheap and easy public access to meteorological data via satellite links. Preliminary plans for such access have been made, but it is not clear whether NOAA intends to provide the raw data or tailored data, the latter of which would have the unfortunate effect of cutting out the private sector and the research community.

The present National Weather Service operated system, AFOS (Automation of Field Operation Service) will be replaced in a few years by AWIPS (Advanced Weather Interactive Processing System). This will be a valuable aid to the severe weather forecaster (see Section 3) but should also be accessible to agencies and individuals outside NOAA, unlike AFOS. In this way NOAA and the private sector could exist in a more symbiotic relationship.

2. ROUTINE FORECASTING

Although not part of its original raison d'être, the U.S. Weather Bureau gradually became involved in "routine forecasting" which seeks to inform the public of nonthreatening changes in the weather. Over the past two decades, this activity has been gradually shifting over to private sector interests, including private corporations and media forecasters. It is difficult to argue that routine forecasting is a federal responsibility, and private interests have proven highly successful in this enterprise. In many major cities, one hardly ever hears a National Weather Service Forecast since virtually all television and radio stations have their own forecasters and newspapers often obtain forecasts from private firms. This duplication of effort presents an opportunity for the National Weather Service to save money and to concentrate their efforts on the business of warning, which is a special responsibility of government. Moreover NOAA, rather than resisting the trend toward private sector forecasting, should instead promote it by providing cheap and easy access to raw weather data which has been paid for by the taxpayer.

3. HAZARDOUS WEATHER WARNINGS AND WATCHES

Warning the public of hazardous weather is probably the most important function of NOAA. Over the last fifty years spectacular reductions in the loss of life caused by weather phenomena have been achieved through the establishment of an effective warning system. This is an accomplishment that NOAA can be proud of. As technology and science develop, our ability to provide adequate warnings of severe weather will further improve. It would be difficult to overestimate the importance of the warning system. In 1985, a single hurricane caused $1 billion damage in the U.S. In 1970, a hurricane in Bangladesh killed 300,000 people who were not warned and probably could not have been evacuated if they had been. We in the U.S. have been luckly for about 20 years, but we must remember that the worst natural catastrophes in U.S. history have been hurricanes: Galveston, 1900, in which about 6000 were lost and the Okeechobee storm of 1928 which took 4,000. The difficulty of rapidly evacuating large populations from certain coastal regions makes early warning of crucial importance.

Hurricanes, and to a somewhat lesser extent blizzards, are phenomena that move coherently over periods of days and can be forecast fairly successfully. The National Hurricane Forecast Center in Coral Gables does a superb job in tracking hurricanes and issuing warnings; their task is vital to public safety. But many dangerous weather phenomena occur so quickly that entirely different warning strategies are needed. Flash floods are perhaps the most lethal of these events, and lightning and tornadoes are other examples. About 200 people are killed every year by lightning alone. Many aircraft accidents are caused by very rapidly evolving weather events and the number of deaths per passenger mile due to weather-related accidents has shown no significant decline in thirty years.

The present system for providing warnings of small-scale weather events has many components. The National Severe Storms Forecast Center in Kansas City monitors large-scale conditions of the atmosphere and issues watches for relatively large regions that it deems susceptible to the development of severe local weather conditions. My colleagues and I have high regard for this agency. Actual warnings to the public, which require immediate action, are issued locally by weather service offices often only after the event is in progress. Examples include tornado, severe thunderstorm and flash flood warnings. In a somewhat different league are the flight terminal forecasts and marine forecasts issued by the National Weather Service; while these are issued routinely, they are certainly crucial to public safety and are thus legitimate and necessary functions of the federal government.

Weather events that last from a few minutes to a few hours are generally referred to as "mesoscale" phenomena, and forecsting severe weather of this scale presents a difficult but important challenge. The main difficulty is that the forecaster must digest extremely large volumes of data in a very short time. Both the science and the technology pertinent to this task are developing very rapidly at this time.

For example, Doppler radar makes it possible to detect rotating wind patterns within thunderstorms that appear as much as ½ hour before tornadoes develop, allowing trained forecasters with efficient access to the radar data to issue warnings before the event actually occurs. (Today, most tornado warnings are issued only after a tornado has actually been spotted.) Doppler radar may also be used to infer the presence of strong downdrafts called "microbursts"; these are responsible for a number of fatal aircraft accidents, including, for example, the recent crash of Delta Flight 191 at Dallas. Although Doppler radar has been used by scientific researchers for well over 15 years, the present National Weather Service radar network is based on technology developed in the late fifties. The NEXRAD (Next Generation Radar) program is essential if we are to take advantage of this new technology. But it must be pointed out that the advent of high technology will be a waste of time and money unless forecasters are highly trained in the use of the new technology.

In addition to radar, other sensing devices are critical to successful warnings of severe mesoscale weather systems. They include satellite observation, ground-based direct measurements and real time lightning locaters. While all of this data is useful, assimilating it in a timely and effective way requires new approaches to the man-machine mix. The PROFS (Program for Regional Observing and Forecasting Services) represents an attempt by NOAA to develop new techniques and technology in support of mesoscale forecasts. Its success would greatly improve NOAA's ability to provide ample and effective warnings.

4. OPERATIONAL NUMERICAL WEATHER PREDICTION: THE NATIONAL METEOROLOGICAL CENTER

One of the vital tasks of the National Meteorological Center (NMC) is the development and routine application of mathematical models which are used to predict the future state of the atmosphere up to several days in advance. These models start with the current observed state of the atmosphere and integrate the equations governing motion, mass and energy forward in time to produce quantitative forecasts. These models require state-of-the-art computers. After numerical weather prediction was started in this country in the fifties, the accuracy of forecasts improved spectacularly, achieving a plateau in the early seventies. At this time, the routine use of these models is a task that is far too large for the private sector. Numerical weather prediction is an important function of NOAA not only in providing guidance for routine forecasts but ultimately in aiding the task of severe weather warning.

Until recently, NMC was at the forefront of operational numerical weather prediction. There is a widespread feeling in the meteorology community, however, that the European Center for Medium Range Forecasts (ECMWF) has pulled ahead of us in this field. (The higher accuracy of ECMWF forecasts was highlighted in a front page New York Times article this past February.) I and many of my colleagues feel that there are two main reasons for this decline. First, NMC has been underfunded. Until last year, NMC relied on relatively old, slow computers and the machines in use today are still no match for the CRAY computers used by ECMWF. The second reason, which is partially related to the first, is that NMC has been isolated from researchers at other laboratories and at universities. This has been a substantial hindrance to progress at NMC. The lack of interaction of NMC with universities has, I believe, two main causes. The first is that university scientists are generally funded by agencies (such as NSF) that do not encourage application-oriented research. The second is that the system of incentives within NMC is not conducive to in-house basic research. What is needed is a cooperative effort between NOAA and the universities (perhaps represented by UCAR, the University Corporation for Atmospheric Research) by which an environment conducive to research in operational numerical weather prediction can be created. The director of NMC, William Bonner, appears to be very interested in establishing closer ties with universities. I believe that the improvement of models and data assimilation techniques that would be fostered by closer ties with the research community would place NMC back where it belongs at the forefront of operational modeling. Dr. Bonner should be supported in his efforts and NMC should be given additional means to expand its own research staff and establish visiting scientist positions. Numerical weather prediction was invented in the United States and it is vital to the national interest. We have by far the greatest concentration of meteorological talent in the world, and yet we are behind in numerical weather prediction. This state of affairs can and should be corrected.

5. RESEARCH IN SUPPORT OF NOAA'S OBJECTIVES

Improvement in the execution of NOAA's responsibilities rests on applied and basic research, both within and outside NOAA. The various Environmental Research Laboratories (ERL) operate in support of this research. There is a question of how much of this research should be performed by NOAA and how much should be contracted out. The present state of the laboratories appears to provide a balanced mix, though the quality of the various laboratories ranges over a broad spectrum. Again, there is a problem of relatively small interaction with outside agencies which is partially due to the relatively small budgets of the laboratories. A good example of an ERL lab is the National Hurricane Research Laboratory (NHRL), which performs research in support of forecasting hurricanes. The laboratory supports high quality research aircraft which no smaller agency could support, and encourages outsiders, such as university scientists, to collaborate with in-house scientists in experiments using the aircraft facility. As a result, much has been learned about hurricanes and better forecasts are just one benefit. The various aircraft have also been used to good effect in support of other field programs during times other than the hurricane season. The high quality of the individual scientists and of the research facility coupled with a reasonable flow-through of outside scientists make this a productive laboratory.

NOAA also supports research by contracting with outside scientists and by its involvement in field experiments, which often require large, coordinated efforts involving many scientists and facilities. I wish to point out what I believe to be an unfortunate tendency in the planning of such experiments. While major field experiments are sometimes required to accomplish certain scientific objectives, it is often true that individual lines of scientific research are better served by much smaller, carefully designed experiments under the control of a single investigator or a small group brought together naturally by a common scientific objective. There is the widespread perception, however, that Congress prefers to fund a few high profile efforts that it can easily point to when asked what it has to show for the taxpayers' money, whereas it is far more difficult to illustrate genuine advances made by many smaller projects, even though they may be more effective in advancing science. The result is that scientists are sometimes brought together more from the perceived advantage in acquiring resources than from strictly scientific objectives. I believe that Congress must resist the temptation to lump all science together into a few big programs, in light of the fact that most progress comes from individuals and small groups, though major programs are sometimes warranted from a strictly scientific standpoint. That is to say that the role of the individual in science continues to be of paramount importance.

I make these remarks as a preface to confessing a certain ambivalence toward the proposed STORM (Stormscale Operational and Research Meteorology) program, which NOAA is partially funding. It appears to be motivated principally by a desire to field test a promising new device called a wind profiler, which uses a form of Doppler radar to deduce winds through the depth of the atmosphere at the radar sites. Its main advantage over the rawinsonde is that it provides continuous measurement of wind for very little labor, but it does not adequately measure other important variables such as temperature and moisture. While the profiler will no doubt prove a highly useful addition to NOAA's measurement system, it seems premature to field test these on the scale proposed. Moreover, the scientific objectives would probably be better served by a number of smaller programs. There is no doubt, on the other hand, that much will be learned if STORM is funded, even though it may not be particularly cost-effective. My view of this may very well be a minority view among meteorologists.

CLOSING REMARKS

NOAA serves several vital functions of the federal government. In the general area of weather prediction, it has the responsibility of collecting and disseminating meteorological data, of issuing warnings of hazardous weather events, of operational numerical weather prediction, and of supporting research in aid of these activities. While there is room for improvement in all of these areas, NOAA generally carries out these responsibilities in a highly effective fashion. Some important divisions of NOAA are seriously underfunded, but there is an opportunity for the National Weather Service to shift resources from routine forecasting, which can and is being done effectively by the private sector, to other activities which are its special responsibilities. In this report, I have made several recommendations which are summarized as follows:

1. While NOAA's satellite program is a vital part of its activities, more attention needs to be paid to direct measurement systems and the agency should investigate whether such systems developed outside NOAA may be adaptable to its purposes.

2. NOAA should provide cheap and easy access to the raw data it collects. This would allow private sector meteorology to flourish and facilitate research in meteorology, both of which are directly in the public's interest.

3. NOAA should leave routine forecasting to the private sector, where possible, and focus its resources on data collection and dissemination, severe weather warnings, research, and operational numerical weather prediction.

4. The advent of new technology should greatly increase NOAA's ability to provide timely and effective warnings of severe local weather. Programs such as NEXRAD should be supported, and steps must be taken to assure that NWS personnel are adequately trained in the use of the new technology.

5. The United States has fallen behind western Europe in the field of operational numerical weather prediction. This situation can be greatly improved by creating environmental conducive to the interaction of NOAA scientists with outside researchers.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR KERRY AND THE ANSWERS

Question 1. In your opinion what are the best ways to improve marine weather forecasting?

Answer 1. Marine forecasting is among the most important functions of NOAA since the safety of coastal and offshore commercial shipping, fishing and recreational boating is at stake. The forecasting problem can be divided into two parts:

a. Forecasting weather systems that develop over periods of one to several days. These include hurricanes and severe extratropical winter storms.

b. Forecasting weather systems that develop over periods of several hours, such as severe thunderstorms.

Many of the problems in forecasting systems in a) above are related to the general forecasting problems I alluded to in my testimony. But marine forecasting is hampered more than anything else by an almost complete lack of weather observations at sea. It is a myth, which I am afraid NOAA has helped perpetuate, that satellite observations have obviated the need for actual (hard) data collected by direct measurement. The actual number of observations reported by commercial shipping is in decline and NOAA has removed all weather ships which were formerly a source of balloon measurements through the depth of the atmosphere. Recently installed buoys and commercial aircraft observations have helped fill the gap, but much more can and should be done.[1] The two most important actions NOAA should take are, in my opinion.

a. Undertake a vigorous program to implement automated surface and upper-air observations from commercial ships, and

b. Provide easy and cheap access to the data via high speed data links to government and private forecasting groups and via direct radio broadcast to ships and sea. (I do not mean "NOAA Weather Radio" which is strictly coastal and which commonly broadcasts observations 6 or more hours out-of-date.)

Both of these actions could be easily accomplished for a small fraction of what it costs to launch a single satellite.

Question 2. You suggest that NOAA consider saving money by deemphasizing routine weather forecasting.

Do you believe that substantially reducing routine forecasts would reduce the number of personnel needed for National Weather Service offices?

Aren't personnel levels determined primarily by Weather Service needs in time of emergency?

Answer 2. It is simply bad economics to maintain a large staff of forecasting personnel for the handful of emergencies that occur each year. As a consequence, NWS forecasting offices are understaffed for emergencies, as anyone working there will attest. The solution, I believe, is to centralize the forecasting operation while at the same time having it focus exclusively on severe weather. A forecast office should serve a region large enough that severe weather in the region is more nearly a weekly, rather than a yearly, occurrence. This would justify a level of personnel consistent with emergency situations and would both make the job much more satisfying and keep the forecasters at a high level of training.

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[1] The importance of direct observations is highlighted by a recent lawsuit against NOAA (Honour Brown vs. United States of America, CA 81-168-T) revolving around the loss of several fishermen during a severe winter storm at sea. It was contended that the failure of NOAA to maintain a crucial data buoy resulted in a lack of data that led to a faulty short-term forecast of the storm's track and intensity. Regardless of the merits of this particular case, more and better data would probably have averted the tragedy.

Question 3. You mention in your testimony the importance of training forecasters in the use of new technology like NEXRAD.

Do you have reason to believe that training in the new technology will not be adequate?

Isn't one of NEXRAD's great potential advantages its easily-used training manuals and instructions?

Answer 3. My knowledge of the plans for personnel training in NEXRAD is admittedly sketchy. I do know that in the past there have been widespread complaints of inadequate training of NWS personnel and that the focus of NEXRAD technology is to make it largely independent of forecaster intervention. (For example, there is a large emphasis on developing software for automatically detecting tornadoes and microbursts.) I fear that the philosophy of substituting sophisticated technology for human intelligence may be taken too far.

Question 4. NOAA has proposed a $2 million reduction in the PROFS system. Do you think this is a mistake? Please state in more detaii why you like the PROFS approach.

Answer 4. PROFS emphasizes the constructive interaction between observing systems, automated data analysis and human forecasters which I believe is necessary for adequate forecasting of short time scale severe weather phenomena. PROFS was an experiment along these lines which could set an example of the kind of forecasting operation I discussed in point 2 above. Perhaps NOAA management feels that PROFS has successfully achieved its goals in which case it can be gradually phased out.

Question 5. In your testimony you state the importance of university researchers working on operational numerical weather forecasting.

To your knowledge has the National Meteorological Center ever had positions for visiting university scientists?

Would the lack of computing power at the NMC hinder the effectiveness of a cooperative effort with the universities?

Answer 5. The National Meteoroglogical Center has not, to my knowledge, had visiting positions for university scientists until very recently, or if it did, their availability was not widely known. There are now a few visiting positions which are funded via the University Corporation for Atmospheric Research by the National Science Foundation. This is an excellent idea which might be expanded upon. Until quite recently the computing power at NMC was inadequate even for the forecasting operations, let alone research. Now NMC has a second computer which serves as a backup for the machine used for operational numerical weather prediction as well as for research, and is planning a third to be used exclusively for research. These are certainly moves in the right direction and should be supported by NOAA management.

Senator **Kerry**. I appreciate that, and I know they appreciate the last comment. I think all of this oversight effort is taken in the context of constructive input and not otherwise, but I appreciate that.

We have been very lucky so far, since we began this hearing, but we now have a vote on, and, Dr. Baker, I would like to ask you to commence your testimony. I think we ought to be able to get within the five-minute limit or so. But when the five lights go off, or somewhere shortly thereafter, I am going to have to—the seven-minute warning—I will have to spin out of here.

Dr. Baker.

Dr. **Baker**. Thank you, Senator Kerry.

Let me just focus on two areas. In the area of climate change, the fiscal year 1988 NOAA budget is deficient. Today we know that there are both natural and man-induced climate change, but we do not understand how these processes work. We cannot predict the

El Nino and its global manifestations, including enhanced heavy rains during monsoons. There are important consequences.

In the U.S. the tropical weather patterns influence the path of storms and hurricanes, leading to heavy rains and mudslides. In countries around the world consequences are equally drastic. In Bangladesh, the green revolution has enabled farmers to grow crops that increase the yield manyfold. But the yield is highly dependent on the time of the harvest, which in turn is dependent on the monsoon. But to understand when the monsoon will come, we need to understand the global interaction of the atmosphere and the ocean.

If we had an ability to predict, we could save large sums of money. For example, during 1982, if we had predicted the El Nino, we could have modified the payment-in-kind program, subsidizing crops that would have been needed around the world and not subsidizing those that would not have grown anyway.

An international program called the Tropical Ocean Global Atmosphere Program is now under way to describe and understand such processes. NOAA is the leader in that program, yet the new budget proposes to reduce TOGA funding. The proposed reduction of $3 million in the fiscal year 1988 budget for the TOGA program could jeopardize the entire worldwide program. This decrease should not be approved.

Let me turn as a second example to the issues of satellite measurements of land processes. To understand man's impact on the atmosphere because of adding trace gases, it is necessary to understand biological processes. For example, in the southern hemisphere, more dimethylsulfide is emitted by marine plankton than is produced by man from factories. Satellite measurements are the key to describing and understanding this process and the NOAA request for support of Landsat commercialization has broad support in the community of earth scientists.

The data from Landsat 4 and 5 and the French SPOT satellite have given us a new view of how the earth land surface changes over periods of several years. This continuing data will be an essential part of understanding the earth as a system and in predicting global environmental change.

Landsat 6 has a new instrument proposed to measure ocean color. This data can be used directly to measure marine plankton and hence predict the effect of biological processes on global change, as well as to predict areas of high productivity for fisheries. I urge full support and adequate subsidy for Landsat 6. We need it urgently for research and operational purposes and to meet our international commitments and for our understanding of the earth. Otherwise, we will see the French, Japanese and the Soviet Union overtaking us in this area.

Let me close with a word of warning. As population increases and as the pressure on our resources makes us more aware of man's increasing effect on his environment it becomes clear that we must understand the environment. NOAA programs are the center of this activity, yet NOAA is traditionally underfunded to do its critical tasks. It may be that we should look to new structural arrangements for NOAA, such as an independent agency.

In any case, if NOAA continues to be unable to carry out the tasks assigned to it, then the country as a whole will be the poorer. Thank you.

[The statement follows:]

STATEMENT OF DR. JAMES BAKER, PRESIDENT, JOINT OCEANOGRAPHIC INSTITUTIONS INC.

Senator Kerry, thank you for the opportunity to testify today on the budget authorization for the National Oceanic and Atmospheric Administration. I am D. James Baker, President of Joint Oceanographic Institutions Incorporated, a non-profit corporation whose members are the ten academic oceanographic institutions that operate open-ocean research ships. The research carried out in these institutions is closely tied to the atmospheric sciences, and we look to NOAA as a significant partner in support of both oceanic and atmospheric science. In addition, I am a member of the Climate Research Committee, the Ocean Studies Board, and the Space Science Board of the National Research Council, as well as being a member of the Council of the American Meteorological Society and President-elect of the Marine Technology Society. As a consequence, I am close to many of the issues being discussed here today, but I want to emphasize that I am speaking from my own point of view rather than as a spokesman for any of these groups.

I have provided written testimony for the record, and I will summarize here. NOAA's atmospheric, satellite, and environmental data and information programs are critical to the health and well-being of our society and of societies around the world. New technology has brought us to the edge of major new achievements in understanding and prediction, but without adequate support, we will never reap the benefit of the progress so far. Let me illustrate.

Short-term weather warning and forecasts services are at the heart of NOAA. Today, thanks to major research programs in the U.S. and worldwide, we have a good understanding of what needs to be done to improve those forecasts. We need good observations, and we need high-speed computers to use this data together with models to make predictions. With the proper application of observing and computing systems, we could make major advances in warning and prediction. The FY 1988 NOAA budget addresses these issues.

In the area of providing greater lead time for weather warnings and improved short-range forecasting, the 1988 budget includes funding for limited production for the Next Generation Radar (NEXRAD) program that will replace existing obsolete radars for detection of atmospheric motion patterns within thunderstorms and other threatening weather patterns that lead to tornadoes, squall lines, and heavy snow bands. Such radars can also warn of downdrafts and wind shears that pose hazards to aircraft in landing and takeoff.

The Automated Surface Observing System (ASOS) will provide reliable and continuous surface weather observations. This automated system will provide the essential continuous weather watch that we need in order to be prepared for rapid changes in our environment. The Advanced Weather Interactive Processing System (AWIPS) is an integrating device to provide for the local field forecaster the same capability that has been shown to significantly improve forecasts from the National Severe Storms Center. All of these budget items address major national needs, and their inclusion in the NOAA budget is essential for our nation's progress. Dr. Calio and Dr. Hallgren are to be congratulated for their success in bringing the National Weather Service to this point.

A second area, but one of even greater importance in the long run, is that of climate change. Here, in my view, the FY 1988 NOAA budget is deficient. Today, we know that the climate changes naturally from year to year, and we know that man is affecting the climate by adding various gases like carbon dioxide and methane that make the atmosphere warm up. But we do not yet understand how these processes work. We cannot predict the El Nino and its global manifestations like the monsoons, heavy rains that come in the summer in the tropics. There are enormous and life-threatening consequences.

In Bangladesh, the green revolution has enabled farmers to grow crops that increase the yield manyfold. But the yield is highly dependent on the time of harvest. Ideally, the harvest should come just before the onset of the monsoon, or heavy rains. If the harvest is taken too soon, then the yield is low. If the rains come before the harvest, then much of the crop is lost. Accurate prediction of the onset of the monsoon is crucial to the health of this small country.

But to understand the monsoon, and when it will come, we need to understand the global interaction of the atmosphere and the ocean. This global interaction has been recognized in recent years to be part of the famous El Nino problem: a tightly coupled interaction between the tropical ocean and the global atmosphere. To understand this interaction is a difficult task that will involve global observations by satellites, computation on supercomputers using models and data, and data and information services. An international program called the Tropical Ocean-Global Atmosphere program (TOGA) is now underway. NOAA has been a strong supporter of research and operations leading up to TOGA, and has been a leader in the TOGA program itself. All of these are essential parts of NOAA. The Subtropical Atlantic Climate Studies, Geophysical Monitoring for Climate Change, and studies of Radiatively Important Trace Species are all key programs, and are supported in the new budget.

Yet the new budget proposes to reduce oceanic and atmospheric research, particularly in the area of ocean-atmosphere interaction, where implications for climate, for ocean circulation, and for the fisheries and shoreline economy are world-wide. The proposed reduction of $3 Million in the FY 1988 budget for the TOGA program could jeopardize the entire worldwide program. The decrease should not be approved.

Now let me turn to NOAA's satellite program. The National Environmental Satellite, Data, and Information Services (NESDIS) component of NOAA is key to the development of the global observing system we need for describing and understanding our earth. The Geostationary Operational Environmental Satellites (GOES) observe the eastern and western United States and the adjacent ocean areas from their vantage point 22,300 miles above the equator. They give us continuous coverage of weather events such as hurricanes and severe storms, relay meteorological data from collection points to processing centers, and send images of processed data to field stations.

The TIROS (Television and Infra-Red Observation Satellite) Polar-Orbiting Satellites move in an orbit over the poles and provide operational coverage of the entire earth four times per day. They make measurements of temperature, humidity, cloud cover, water-ice boundaries, and proton and electron flux near the earth. They also collect and retransmit data from stations around the earth.

Satellite coverage of the earth, first achieved by the U.S. in 1960, has been the primary cause of our understanding how the atmosphere works, and has led to the dramatic increase in forecasting ability since that time. It is vital that such coverage be continued; the FY 1988 budget provides for a two-GOES system, which is essential. The budget also provides for a polar configuration that minimizes the risk of a data gap and provides a backup satellite in orbit. This arrangement is also crucial for our country's weather prediction system.

The satellites are essential for weather prediction. But they are also essential for longer-term description and understanding of the atmosphere, ocean, and land surface. It is crucial that we keep the measurements in place, and that there be no data gap. When we study a problem like the El Nino, we need uninterrupted data series of many years in length -- 20 to 50 years is typical. A data gap greatly reduces the usefulness of such series. Congress should ensure that the support of NOAA-proposed satellite programs and launch arrangements is adequate so that such data gaps do not occur.

Finally, let me turn to the issues of satellite measurements of land processes. To understand man's impact on the atmosphere because of adding various gases, it is necessary to understand ocean and land processes, particularly biological ones, as well as what happens in the atmosphere. If tree leaves or marine plankton absorb more carbon dioxide than we think they do, for example, then the projected warming may be less. Or, the biological material may emit gases on its own: in the Southern Hemisphere, more dimethyl sulfide is emitted by marine plankton than is produced by man from factories. We need to know how much of this biological material is there, and how it interacts with the atmosphere, land, and ocean. Satellite measurements are the key; and the NOAA request for support of Landsat commercialization has broad support in the community of earth scientists.

Landsat 4 and 5 have been effective, and the data from these, together with the data from the new French satellite SPOT (Systeme Probatoire d'Observation de la Terre), have given us a new view of how the earth land surface changes over periods of several years. This continuing data will be an essential part of understanding the earth as a system, and in predicting global environmental change.

Landsat-6 has a new instrument proposed to measure ocean color. This data can be used directly to measure marine plankton and hence to predict the effect of such biological processes on global change. In global studies of the earth, the ocean color data is therefore essential. The data can also be used to help improve our fishing industry by identifying regions of high productivity. Thus the proposed Landsat-6 is a key item for both the research and the operational community. I urge full support of an adequate subsidy for Landsat-6; we need it urgently for our understanding of the earth. I can also point out that if the U.S. does not support such a program, there will be no other country that will provide such data until the mid-1990s, and then we may see that other countries are taking the lead in this critical area.

Together with the satellite request, NESDIS is also requesting support for data processing and data distribution through its NOAA-Port program. This is an excellent beginning and should be supported. We are seeing a real and effective effort in NOAA to improve the data systems, and we are seeing a strong interaction with the academic and industrial community in terms of providing the kinds of interactions and services required. Dr. Calio and Dr. Pyke are working in close harmony with the community here, and they deserve full support from Congress in this important activity.

Let me close with a word of warning. As population increases, and as the pressure on our resources makes us more aware of man's increasing effect on his environment, it becomes clearer and clearer that we must understand our environment; how it works, how we interact with it, and whether we can predict its changes. NOAA programs are at the center of this activity; yet NOAA is traditionally underfunded to do its critical tasks. I do not know the answer to the problem, but I do know that if NOAA continues to be unable to carry out the tasks assigned to it, then the country as a whole will be the poorer. Thank you.

Senator **Kerry**. Thank you. Thank you for your incredible consideration of those lights and buzzers. This is supposed to be the world's greatest deliberative body, and here we are interrupting your testimony with buzzers and votes and things, and I genuinely apologize for that.

However, I do want you to know that I did read your testimonies. I am aware of what you were going to say. I have questions for each of you, and I know some of my colleagues do. I particularly wanted to talk about how we can better deal with this issue of the amount of information we are going to be gathering from satellites and processing it and where we move, in your comments, on the hydrology and its impact, et cetera, and what we could have done in the Colorado River in forecasting.

I think these are all very, very important statements and the access to raw data issue is a question I intend to submit to Dr. Calio. That is one of those things that we want to follow up on, is how we are going to create better flow of information and guarantee a better end product.

I just want to say for the record, and I mean this, I cannot underscore enough the importance of your testimony or of your being here. I think the Congress needs, all of us need, to be better educated as to the interrelationship of these disciplines and of the opportunities that are presented in this data collection and analysis process with the longer-term choices that we ought to be making that are going to provide for protection of the environment, for food, for shelter that withstands the vagaries of Mother Nature and so on.

And there is much that we can do, and I think you are pointing us in important directions. So I thank you for doing it. Now I would have come back, and I had intended to come back, but I have just been informed by the staff that we are going to have a couple of back-to-back votes. We are on the cloture vote here and there is going to be something following right afterwards, so I am not going to be able to, because of our caucus tied into that.

So I offer you profound and sincere apologies for not being able to follow up personally. However, in terms of the record there will be no lesser impact in your answering the questions I would submit in writing. Obviously it is easier to verbalize it than have to do that, and I apologize for that. But I ask you to please do that because the record will be more complete and our ability to build is better, therefore.

So I thank you very, very much for traveling distance, for coming here, for sharing your thoughts with us, and I hope that we will be able to respond in the way in which you have urged us to, and I think we have a good sensitive Committee here that wants to do it and, I suspect, will do it.

So without further comment, this hearing is adjourned and I thank you very much for coming. Thank you. We will submit to you very promptly the questions in writing so that we can get that done and close the record as soon as possible. Thank you very, very much.

[Whereupon, at 12:08 p.m., the Committee adjourned.]

[The following information was subsequently received for the record:]

STATEMENT OF PROF. RAFAEL L. BRAS

Mr. Chairman and Committee members, my name is Rafael L. Bras. I am Director of the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Department of Civil Engineering, Massachusetts Institute of Technology. I am also an active hydrologist concerned about the little attention given by our science policy establishment to this crucial earth science. I ask for your support of Hydrology in particular as it relates to activities within the Office of Hydrology, National Weather Service, NOAA. Following are general comments on why your support is needed and in particular how Hydrology should play a key role in the Atmospheric and Satellite program of NOAA.

Hydrology is the study of water. Generally, though, it is concerned with the fluxes of water in and out of land masses. This closely ties it to the sister sciences of meteorology and oceanography which deal with fluxes in and out of the atmosphere and oceans, respectively.

Mankind has always been at the mercy of the occurrence of water. Hydrology has then been problem driven, always searching for ways to increase water supplies or predict and manage the effects of natural hazards like floods and droughts. The success of those efforts is evidenced by the high standards of public health and safety enjoyed by the urban populations of developed nations.

But some modern day hydrologic problems require some prognostic rather than reactive studies. For example:

1. Hydrologists efforts to determine the size and recharge rates of underground reservoirs in the Southeastern United States is having, and will have, legal and policy implications that will modify water use patterns and thus preserve options for future economic growth.

2. Our use and abuse of our groundwater systems is now being realized and the abatement of past mistakes is costing billions of dollars. Hydrologists are providing a better understanding of the rate of movement and decay of groundwater pollutants and guiding the continuing search for safe waste disposal sites.

3. The final disposition of high and low level radioactive waste is, on a technical basis, a hydrologic long-term prediction problem of the fate of disposed radioisotopes within the hydrologic cycle.

4. The largely precipitation over the oceans (of interest to hydrologists) is the missing mass and energy input to global climate models and oceanographic models used to predict global phenomena like catastrophic El Nino sea surface temperature anomalies.

5. Agriculture consumes 80% of all fresh waters, a lot of it unnecessarily. The limited water supplies in some of our richest agricultural lands require hydrologists cooperation with soil scientists, agronomists and farmers to find more efficient water management practices.

6. About 200 lives and 5-10 billion dollars are lost every year (in 1986 206 lives and 6 billion dollars) to floods (and many more to related landslides), yet our memories are short and our calls for action only last a few days after a catastrophe.

7. The specter of drought alone is enough to influence our national economy via commodities futures prices. The onset of drought is a devastating, yet common, experience to many regions of our country. Hydrologists must continue trying to predict drought and develop water management tools to deal with such situations.

The above are but a few illustrations of the pressing issues hydrologists must deal with. These issues must be dealt with forthsight, not hindsight.

Water plays such a pervasive role in the affairs of mankind that access to it is globally perceived as a right to be provided by government. Industry and the economy is so dependent on it that no particular sector can be assigned the responsibility of developing the water science. Responsibility is diffused but the impact of neglect is universal. That is why hydrology at the national scale is largely a government concern. Water is a national resource. Good quality water is a scarce resource in much of our nation; it should be treated as such.

Little is spent for research in hydrology. Probably less than 10 million dollars a year is spent extramurally for basic hydrologic research and development by government agencies. This includes all National Science Foundation and U.S.G.S. grants programs. Small quantities indeed, relative to the billions of dollars in related issues and problems.

The Office of Hydrology, within the National Weather Service, is one of the few government agencies whose mandate is to deal exclusively with hydrologic problems. They are required to collect the precipitation data used to predict the state of river basins, yet they have to do so with a network of monitoring stations so sparse that the average volume of water falling over a typical basin in any given storm is at best known with a 30–50% error. It is truly amazing that they are able to do anything. Countries like Japan use significantly denser rainfall monitoring networks. When livelihood and lives depend on your knowledge of nature, better data is a wise investment.

Our national streamflow gaging network is not in better shape. The Office of Hydrology relies on streamflow data collected through the efforts of the United States Geological Survey. The U.S.G.S. in turn depends on state and local governments and other agencies to share the cost of the network. Fiscal pressures have eroded our data base. In 1980 there were 7079 left, a 20% decrease. Of these 540 were fully supported by the U.S.G.S., 3300 operated on a 50/50 cost sharing program with state and local governments, and the remainder were operated by other Federal agencies. The reduction in streamflow gages has resulted in the elimination of flood forecasting services at some locations. Further erosion of this data collection effort will be serious.

Britain and Japan, particularly, have for a long time been committed to improved hydrologic data collection. Their network of digital weather radar and the operating disaster prevention systems that go along with them, have been in development and operation for over 10 years.

With the NEXRAD (new generation weather radar) system, the United States will be taking a major step towards comparable capabilities. Yet the ability to use and disseminate the data that will be available will still lag behind. Digital meteorologic data could potentially allow hydrologists and hydrometeorologists to: a) improve real time prediction of precipitation in a spatially distributed sense; b) use high resolution precipitation data over a basin to improve flood forecasting; and c) improve water budget calculations over regions of the nation with resulting water management benefits.

Weather satellites offer similar potential: a) there are indications that real time precipitation predictions may be improved using weather satellite data; b) the promise of remotely sensing soil moisture conditions over basins would provide the missing link in flood and drought forecasting; and c) the integration of satellite and other data sources has been shown to improve all operational aspects of hydrology.

The promise of radar and satellite remote sensing is clear, but the reality is that the methodology to bring that promise to fruition does not exist. It will not come about until the country invests in its development. The Office of Hydrology, NWS is geared to lead in that task, given the opportunity.

I urge you to consider carefully the needs of Hydrology and the needs of the Office of Hydrology and support any initiatives for improved management of water resources and hydrometeorologic forecasting. We have given them the task to look after and provide information necessary to make the daily decisions so influenced by the state of our river basins and related weather. We should provide sufficient resources to perform the task. Presently that does not seem to be the case. It is estimated that for the whole nation only about 200 people are actively involved in that office to deal with all operational and research aspects of hydrologic forecasting. The total budget for Fiscal Year 1986 was 34.6 million dollars, including their allocation of general purpose activities of the National Weather Service. Extramural research has fallen from about 500,000 to 100,000 dollars, not adjusted for inflation, from the early 1970's to the present.

Let it be understood that the task of the Office of Hydrology is not only operational. Our state of knowledge is deficient; research and development is required. And needless to say education of professionals in this field is crucial. Partnerships between government and educational/research institutions should be encouraged and provided for. They have proven successful in the past. We should try it in Hydrology. The benefits of investing in education and related research multiply many fold beyond the immediate goals of a product.

I thank you for your attention.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Washington, D.C. 20230

Office of Legislative Affairs

SEP 10 1987

Honorable Ernest F. Hollings
Chairman, Committee on Commerce,
Science, and Transportation
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

We are pleased to respond to questions submitted by Senators Kerry, Rockefeller and Pressler in followup to Dr. Calio's May 19, 1987 testimony on NOAA's atmospheric and satellite programs.

If you, or your staff, require additional information regarding these NOAA programs, please do not hesitate to contact me.

Sincerely,

B. Kent Burton
Director

Enclosure

cc: Senator John F. Kerry
Senator John D. Rockefeller, IV
Senator Larry Pressler

Questions Submitted by Senator Rockefeller

QUESTION 1: How many counties in West Virginia have fully operational IFLOWS systems in place? Please define what you mean by operational.

ANSWER: Operational means the counties are receiving data from a network of radio reporting rain gages and also have a voice communications system in place which can be used to communicate with neighboring counties, the State Emergency Operations Center (EOC), or National Weather Service (NWS) offices. Ten counties are fully operational: Cabell, Fayette, Greenbrier, Jackson, Logan, Mason, Mingo, Putnam, Raleigh, and Wayne. During July and August 1987, a new computer is scheduled for installation in each of these counties, which could cause temporary interruptions in operational status as this work is being completed.

QUESTION 2: Please provide the status of the IFLOWS program in all West Virginia counties that are designated to participate in this program.

ANSWER: Of fifteen original counties, the ten fully operational counties are Cabell, Fayette, Greenbrier, Jackson, Logan, Mason, Mingo, Putnam, Raleigh, and Wayne.

All equipment is installed in Boone, McDowell, and Wyoming Counties, which will become operational when the West Virginia Emergency Medical Services (EMS) completes installation work at its Kopperston microwave site. This work is expected to be completed no later than mid-September 1987.

All equipment is installed in Pocahontas County, but development of a radio relay site is necessary to provide a tie-in with other counties. Kanawha County had been fully operational but recently has relocated to a new site which will require additional radio equipment. The necessary equipment for Pocahontas and Kanawha Counties has been identified, and the procurement process has begun.

The expansion counties which are being supported by special congressional funds are in various stages of implementation. A partial shipment of rain gages for these counties has been shipped to the EOC, with final delivery expected by August 1, 1987. Of the approximately 200 new gage sites for the expansion counties, 38 landowner agreements have been obtained, and another 20 are near approval. The computers for the expansion counties have been shipped to county EOC's and are expected to be installed beginning in August. Remaining communications equipment, such as radio transceivers and antennas have been identified but not yet purchased. These counties are: Barbour, Berkeley, Braxton, Calhoun, Doddridge, Gilmer, Grant, Hampshire, Hardy, Harrison, Jefferson, Lewis, Marion, Marshall, Mineral, Nicholas, Monongalia, Morgan, Ohio, Pendleton, Preston, Randolph, Taylor, Tucker, Tyler, Upshur, Webster. Lincoln and Mercer Counties had declined to participate in IFLOWS several years ago but have recently reversed their decisions, and their status is identical to the 27 expansion counties mentioned in this paragraph. Summers and Monroe Counties have been approached, but both have declined participation for lack of maintenance funds. It is possible, however, that the volunteer fire organization in Summers County will fund the project, and negotiations are pending.

QUESTION 3: In March, you told Senator Byrd that of the four original IFLOWS counties (Logan, McDowell, Mingo, and Wyoming), two were not operational because they were awaiting the installation of microwave equipment by the West Virginia Emergency Medical Services (EMS). You also said that Boone County is awaiting its microwave installation. Have these counties made any progress toward getting their microwave equipment? Could you explain to me the need for this equipment? Could you describe the problems that my State is facing in installing this equipment? Is there any way that the Federal Government could help the state in expediting these efforts?

ANSWER: All equipment is installed in Boone, McDowell, and Wyoming Counties, which will become operational when the West Virginia EMS completes installation work at its Kopperston microwave site. This work is expected to be completed no later than mid-September 1987. Because all IFLOWS sites communicate via the EMS microwave backbone, the absence of this key site prevents these counties from tying into the IFLOWS network. One key site necessary to provide communications to the Charleston NWS office is Capitol Overlook.

QUESTION 4: Have Cabell and Mason Counties had their rain gages installed? If not, what is delaying this work?

ANSWER: Cabell County has three proposed gage sites and Mason has two. One site in Cabell County is installed. The gages for all remaining sites are available and ready for installation, but landowner agreements have not been obtained. The State IFLOWS coordinator is currently working with the county officials to obtain these agreements.

QUESTION 5: In March, you also told Senator Byrd that the counties designated for IFLOWS after the 1985 flood were expected by this spring to make their equipment awards. You added that delivery of the equipment should be by this May. Has the equipment been delivered and has installation begun?

ANSWER: Computers have been delivered to each county, and gages were delivered to the State EOC on August 1, 1987. The installation contractor has been selected and expects to begin gage installation work in August. The bid opening for radio equipment necessary to operate the county in a stand-alone mode occurred on August 20, 1987. Other radio and microwave equipment has been identified, and the procurement process has begun. A 2-month delay in the procurement process occurred when the award for gages was contested by one of the competing vendors, and the installation contractor selected was unable to meet the State bonding requirement.

QUESTION 6: In your response to Senator Byrd, you mentioned the problems with the completion of the Statewide microwave communications system. You said that due to delays in installing this system, you are designing alternative ways to communicate until the microwave system is in place. Could you describe these alternative forms of communication and tell me in which West Virginia counties they are being used?

ANSWER: The IFLOWS communications design proposes to substitute radio transceivers for microwave transceivers in areas where the microwave does not yet extend. The radio transceivers are relatively inexpensive and easy to install and will suffice until the microwave system is ready. Currently, one radio transceiver is in place at Keeney Mountain to serve Greenbrier and Pocahontas Counties. The State has been given specifications for purchase of the radio transceivers to serve Barbour, Berkeley, Braxton, Calhoun, Elkins NWS, Gilmer, Hampshire, Hardy, Jefferson, Marshall, Mercer, Mineral, Monroe, Morgan, Nicholas, Ohio, Pendleton, Preston, Randolph, Tucker, Tyler, and Webster Counties.

QUESTION 7: I understand that some parts of West Virginia do not receive weather information from NOAA radio because there are no transmitters in these areas to pick up NOAA radio broadcasts. Do you know, or could you assess, how many transmitters West Virginia would need to be fully covered? What would it cost to install transmitters in these "dead" spots in West Virginia? Are these transmitters usually paid for by the State, the Federal Government, or both?

ANSWER: Due to the mountainous terrain in most areas of West Virginia (the cause of the "dead spots"), total coverage may not be possible and, if it is possible, it could be at considerable expense and therefore not cost effective. Due to the line-of-sight signal propagation characteristics of NWR transmitters (i.e., signal coverage is limited by the terrain) there is a strong possibility that a significant number of transmitters and a complex network configuration scheme would be needed to ensure that a reliable signal is present in all currently unserved valley areas. The number of additional NOAA Weather Radio (NWR) transmitters needed to provide coverage to all existing unserved areas ("dead spots") within West Virginia is not known. To estimate the costs of eliminating NWR "dead spots," the total number of transmitters needed must be determined and the specific design requirements for the network and individual transmitter sites must be analyzed and defined.

Federal funds are currently supporting a level of service comparable to other States. Additional stations could be implemented in West Virginia only if State or other sources of funds become available for the specific NWR locations that include money for not only the equipment, but for installation, annual recurring expenses for transmitter control links, maintenance, electrical power, leases, etc., plus programming equipment and personnel, if needed.

QUESTION 8: I am very concerned about the transfer of flood information from the IFLOWS rain gage to the community. While I understand that the information is sent to a computer within the community, it's not clear to me that the volunteers within the communities know how to adequately interpret the information. What kind of training program does the NWS provide for these volunteers in the communities? How often do you provide training in West Virginia? Please supply me with the training schedule.

ANSWER: Because of the relatively high turnover of flood warning coordinators, particularly at the county level, NWS and the State place importance upon training. NWS provides primary training to State flood warning coordinators, who, in turn, conduct warning preparedness training sessions for county flood warning coordinators. NWS employs a full-time warnings preparedness meteorologist in Parkersburg dedicated to work with counties on most flood warning aspects. The meteorologist gives training to volunteer flood observers on an "as needed" basis. NWS also provides periodic training to State coordinators as new software is developed. The most recent training session in West Virginia was in late July 1987. To supplement the West Virginia coordinator's role, the State recently appointed a qualified individual to work part time with the counties on a one-on-one basis in becoming more familiar and comfortable with operation of IFLOWS computers. A class, conducted by both NWS and State personnel on IFLOWS computer and warning aspects, was held on August 21, 1987, at Jackson's Mill, West Virginia. The State is currently negotiating with the Federal Emergency Management Agency to acquire funds to support training of the flash flood coordinators and IFLOWS computer operators.

QUESTION 9: I am told that at least one West Virginia county (Mason County) has returned their IFLOWS systems, saying that they lack the money to maintain it. Are there any other West Virginia counties that have said that they don't have the money to maintain their systems? While I recognize that the Federal

Government cannot pay for everything, do you have any advice to these counties that are too financially strapped to pay their maintenance costs?

ANSWER: Mason County has not returned its IFLOWS system but has written the State a letter expressing its concern that it may be unable to continue its participation for lack of funding. Budgetary concerns have also affected or have been expressed by Lincoln, Kanawha, Summers, and Monroe Counties. NWS recognizes the limitations of county budgets and has an ongoing effort to improve the maintainability of IFLOWS equipment. One of the major efforts now underway is to install solar panels on rain gages to extend battery life; thereby reducing maintenance calls. The computer in Mason County has been especially troublesome and is being replaced by a new unit of more current technology and reliability. NWS is hopeful that the effect of equipment upgrades and training programs will relieve the counties' budgetary concerns.

QUESTION 10: I know that some West Virginia counties have not signed the Memoranda of Understanding (MOU) that they are required to sign in order to take part in the IFLOWS program. Could you tell me why these counties are refusing to participate? Is the NWS taking any steps to encourage their participation?

ANSWER: Each county which has declined to participate in IFLOWS has done so on the basis of its concern over future equipment maintenance. As explained in the answer to Question 9, NWS is attempting to relieve the counties' concerns through equipment upgrades and education.

Questions Submitted by Senator Kerry

QUESTION 1:

One of today's witnesses notes that the private sector provides ample routine weather forecasting and suggests that the National Weather Service could save money by de-emphasizing routine forecasting.

-- Do you agree that budgetary savings can be achieved by de-emphasizing routine forecasting? If so, what are you doing in this respect?

ANSWER: The process of providing a timely and accurate weather warning service relies fundamentally on understanding and anticipating the evaluation of the atmosphere on all space and time scales. The NWS forecast program provides this basis for the warning service.

Routine NWS forecasts focus on areas of potential significant weather and heighten public awareness of the events which most probably will require future warnings.

QUESTION 2:

What is NOAA doing to encourage university research in operational numerical weather prediction?

ANSWER: NOAA's National Meteorological Center supports university research in numerical weather prediction in a variety of ways:

1. The National Meteorological Center has a fellowship program with the University Corporation for Atmospheric Research to bring in students, recent university graduates and university faculty to work at the Center on problems of numerical weather prediction. This program, now entering its second year, has thus far involved 11 scientists from the National Center for Atmospheric Research and various American universities and 7 students, spending periods of 2 months to 1 year working at NMC.

2. NMC scientists working in numerical weather prediction publish papers and attend meetings through which there are numerous informal interactions with university scientists working in the same areas. NMC work and its daily involvement in operational weather prediction itself serves as an impetus to the more academically oriented numerical weather prediction studies in this country. Eight NMC scientists are available as advisors in the National Research Council Fellowship Program for recent

postdoctoral students in numerical weather prediction. Two NMC scientists have appointments as adjunct professors at universities.

3. NMC makes available routinely through the NWS family of services forecast fields produced by the NMC models. These fields are picked up by the University Corporation for Atmospheric Research through its Unidata Program and distributed to member universities for use in research and teaching.

4. NMC has a very small grant program with several universities to foster research on particular problems in numerical weather prediction. The grant program funds specifically earmarked for numerical prediction research in FY 87 totaled $189,500.

5. NMC is exploring, with the National Science Foundation (NSF), cooperative programs to foster NWP research through a targeted NSF announcement of opportunity emphasizing cooperative efforts with NMC scientists and programs.

QUESTION 3:

What is the status of the NOAA plan for reorganizing the National Weather Service? Please discuss the general nature of this plan, including the likely personnel savings.

ANSWER: During the last several years, NOAA has undertaken intensive technical planning to integrate major new technologies for observation of destructive weather phenomena, analysis of weather and hydrologic data from all sources, and timely dissemination of warnings and forecasts to the public and user agencies. These major technologies which form an interlocking system to provide weather warnings and forecasts include NEXRAD Doppler radar, the Automated Surface Observing System (ASOS), the Advanced Weather Interactive Processing System (AWIPS), as well as major meteorological satellite and supercomputer upgrades. The fundamental purpose of the modernization of virtually all of the major NWS technologies is to improve significantly weather and flood warnings and forecasts to the public, particularly for the most destructive weather events.

During the course of technical planning, it became obvious that the entire operational and organizational structure of the NWS would have to be adjusted in order to utilize the new technologies effectively to meet the goal of improving weather warning and forecast services to the public. Detailed proposals for an integrated modernization of the technologies and operations of the NWS are currently under review within the Administration.

QUESTION 4:

What would be the impact of funding NEXRAD, ASOS, and AWIPS at last year's levels?

ANSWER: NEXRAD - NEXRAD is a tri-agency effort which draws funding and personnel resources from the Departments of Commerce (DOC), Defense (DOD) and Transportation (DOT). Competitive proposals for the production phase of the program were received in 1986 and Best and Final Offers on June 12, 1987. Selection of a production phase contractor is expected during September.

A reduction in funds available for the scheduled start of full-scale production in FY 1988 would require extensive renegotiation of delivery schedules to stretch the program out if funding were restored in future fiscal years or a reduction in the scope of the program by matching costs to available resources. Direct cost increases would result from a stretch out and a lengthy proposal resubmission and renegotiation process would probably add a minimum 6 months delay to the program and further increase program costs.

ASOS - This would cause a reduction in the scope of the program or a delay of at least one year in the ASOS schedule if funding were restored in future fiscal years. NWS currently plans to award the pre-production phase contracts for the ASOS procurement in FY 1988. The Request for Proposals for this effort has recently been released, and without the FY 1988 funding increase there would be insufficient funds to award the subsequent contracts. These contracts are planned to be executed in conjunction with the Federal Aviation Administration and a deferral at this time would have serious impact on the joint agency program.

AWIPS - Holding AWIPS funding at the FY 1987 level through FY 1988 would cause at least a 6-12 month delay in the AWIPS program schedule if funding were restored in future fiscal years or a reduction in the scope of the program.

Without the planned increase, there would be insufficient funds available to award the AWIPS Definition Phase contracts in FY 1988. In addition, technical contract support to the program in areas including quality assurance and applications software development would be reduced by approximately 25%, and development, testing, and risk reduction activities essential to establish readiness for introducing the new technologies would have to be reduced or deferred. This would significantly increase the likelihood of encountering unforeseen problems when they are much more costly to correct.

QUESTION 5:

Fishermen, boaters, and other mariners have long complained that marine weather services fall well short of what they should be.

-- What are the main difficulties experienced by NWS in providing good forecasts of marine weather?

-- What are you doing to improve marine weather forecasts and warnings?

ANSWER: There are 3 main difficulties. First there are fewer observations of the weather elements in the marine environment as compared to land areas. The accuracy of a forecast depends on the amount of present and past information describing the conditions to be forecast. To illustrate the problem, the area of the Nation's 200-mile offshore Exclusive Economic Zone (EEZ) equals 70% of the U.S. land area. Yet ocean and Great Lakes observations used for issuing marine warnings and forecasts are only 20% of the amount of data available for weather services over the equivalent land area. Marine data coverage averages one observation per 12,500 square miles of the EEZ, an area about the size of Massachusetts, Connecticut, and Rhode Island. However, increasing those observations would not necessarily be cost effective since a much larger portion of the population benefits from land-based observations.

Second, the marine environment is very complex. Heat exchange between air and sea, nearshore and deep ocean currents, irregular coastline, land/sea temperature differences, and underwater topography combine to produce small scale changes in winds and waves over time and distance which often are not detected either by surface marine observations or by satellites.

Third, we have an imprecise understanding of the marine environment. The mathematical models which attempt to describe the physical characteristics of air/sea interaction are inaccurate. Much of this refinement requires an expanded network of marine observations.

Efforts to improve marine weather services have been focused on expansion of the data network. Where cost effective and as resources permit, additional automated marine observing systems in the form of moored buoys, drifting buoys, and automated coastal and lighthouse stations have been added. At present, there are 58 moored buoys and 40 Coastal Marine Automation Network stations serving as the backbone observing network for warnings and forecasts in the EEZ. A small number of drifting buoys are deployed in the path of hurricanes to help determine intensity and movement. Under an international program, 6300 Voluntary Observing Ships along Atlantic and Pacific trade routes provide observations on the development of major ocean storms. Shipboard Environmental Acquisition Systems have been installed on about 100 vessels for more efficient reporting and satellite communications. To help fill data gaps within the EEZ, a self-help Mariner Report program recruits volunteer fishermen and other small boat operators to provide on-scene weather reports through private coast radio stations to NWS to help update local warnings and forecasts.

Over the next 10 years major changes will be made in weather monitoring and warning technology which are expected to benefit marine services. Next generation Doppler weather radars along the coast will improve the detection of localized severe weather. Advanced interactive computer processing systems and supporting communications networks will speed up data distribution, processing, monitoring, and forecast formulation. Planned all-weather (i.e., through-the-clouds) satellite sensors for observing low-level ocean winds, waves and ocean temperature will provide a major solution to the problem of data sparsity over the ocean and Great Lakes.

In the near term, a Satellite Weather Information System is being planned for installation at forecast offices to provide satellite image automation and blending with other data for improved coastal monitoring.

QUESTION 6:

As in prior years, the Administration proposes to terminate agricultural weather services on the theory that agricultural users can obtain these services from private firms.

-- Given the state of agriculture in this country, and its great variability, has NOAA any concrete information that present users of these services have any genuine private alternatives?

ANSWER: Several private meteorologists are providing services to agricultural interests now. In addition, there are a number of private sector meteorologists operating in various parts of the country that could develop agricultural weather services if given the opportunity and financial motivation. NOAA believes the normal economic motivations will operate and result in the private sector assuming, quite vigorously, the services now provided by NOAA. In prior years, information on our services has been provided to the private sector through a series of seminars which were designed to encourage private meteorologists to develop a capability to provide the required services. These seminars were well attended and correspondence since the seminars indicates that interest is still strong.

QUESTION 7:

Given its importance in developing new techniques and technology for mesoscale meteorology research, why does the Administration propose cutting the PROFS Program by $2 million?

ANSWER: The reduction of the Program for Regional Observing and Forecasting Services (PROFS) by $2 million (or 50 percent) has been proposed because of the reduced need for this facility as the AWIPS program is implemented. The remaining base of $2 million will maintain the PROFS facility and provide adequate support for the implementatioan of the Advanced Weather Interactive Processing System (AWIPS). This will permit operation of the DARRRE (Denver AWIPS-90 Risk Reduction and Requirements Evaluation) on a reimbursable basis. The reduction of $2 million will phase out research that has been completed on long-term improvements in weather forecasts and warnings.

QUESTION 8:

Please describe NOAA's work in acid rain research.

ANSWER: NOAA participates in the National Acid Precipitation Assessment Program, which is addressing the origins and effects of acid rain. The NOAA research has focused on the following atmospheric components of the phenomenon:

- Determining the natural emissions that form the background acidity of deposition;
- Characterizing the chemical and meteorological processes that form acids from natural and man-made emissions; and
- Monitoring the amount, frequency, and range of acidic material deposited on the surface.

This research consists of short- and long-term field measurements, laboratory studies, and theoretical modeling of the processes linking emissions from one area to deposition in another area. The major NOAA activities and conclusions follow.

Natural Emissions

There are substances that are emitted from natural sources on the land and the ocean that, in some cases, can significantly influence the formation of atmospheric acids, alkaline materials, and oxidants (such as ozone). NOAA has developed instruments and techniques to measure these substances, conducted field measurement campaigns across the U.S. and in coastal waters to establish the details of the emissions, and prepared emission inventories. These results demonstrate that:

- Natural nitrogen emissions (lightning and soils) and sulfur emissions (vegetation, soils, and ocean biota) are only a few percent of man-made emissions in the eastern U.S. The only places where such emissions are significant are coastal areas.

- Natural alkaline dust from soil erosion and traffic on unpaved roads is a significant source of airborne material that can neutralize some of the acidity in deposition. The most important source areas are the mid-U.S., and the amount of material depends on dryness. As a consequence, alkaline dust can cause a climatological variation of the recorded acid deposition in the vicinity of these areas.

- Natural hydrocarbon emissions from vegetation in rural areas in the eastern U.S. are found to be comparable in magnitude to man-made emissions (automobiles and industry) in those regions. These emissions play a substantial role in the formation of ozone, which influences the production of acids and which is a pollutant itself. These natural emissions will influence any acid or oxidant control strategy.

Atmospheric Processes

Since the substances emitted from both natural and man-made sources are not acids, it is crucial to understand the chemical processes that change these substances into acids during their transport in the atmosphere. NOAA research in this regard has employed the development and testing of new instruments, airborne and ground-based measurements in regions where key processes occur, measurement in the laboratory of the fundamental rates of chemical reactions, and the development, testing, and application of theoretical numerical models that simulate how emissions are transformed into acids, transported to different regions, and deposited to the surface. These studies have found that:

- The clear-air chemistry that converts sulfur dioxide (the primary sulfur pollutant) to sulfuric acid has been shown to not deplete the natural atmospheric oxidants. This means that, in the clear-air formation of acids, more sulfur dioxide emissions mean proportionally more acids and vice-versa. This linearity is an important step in building a control strategy.

- Field measurements have discovered that in some regions, notably the west, there are yet unknown nitrogen compounds that may contribute to nitric acid formation. This observation has placed a substantial uncertainty on the ability to model nitric acid deposition in these areas and has spurred the search for the identity of these compounds.

- Airborne studies along the east coast have shown that as much as half of the pollutants produced in the U.S. are transported and depositd offshore. These data help define what receptor areas are influenced by North American emissions.

- Ground-based studies in the eastern, central, and western U.S. have shown that a substantial fraction of the ambient ozone levels in the troposphere are due to chemical processes, rather than the natural source of downward transport from the stratosphere. Furthermore, in rural areas in the east, natural and man-made hydrocarbons and nitrogen oxides are the major controlling factors in the production of ozone. Since ozone is a primary player in acid formation, these results show that a complete strategy cannot be based on the acid precursors alone.

- The comparison of theoretical predictions to observations of emissions, oxidants, and acids indicate that the present theory of how the oxidants are formed and destroyed is somewhat deficient, namely, the theory, for reasons yet unknown, overpredicts the abundance of a key oxidant. The deficiency is a major current research focus.

- NOAA has conducted field experiments using chemically inert tracers to study the influence of atmospheric transport and diffusion on pollution distribution. Data from these experiments have provided a critical test of pollution transport and dispersion calculated by Regional Acid Deposition Models.

Deposition Monitoring

Regular, accurate, and long-term measurements of acid deposition are the key to detecting trends, revealing signatures of processes, and pointing out the areas where effects studies must concentrate. NOAA has developed methods for such monitoring, established regional and global networks of deposition monitoring stations, and helped compile and distribute such data. Some of the major accomplishments are:

- NOAA has one of the longest records of wet deposition at its 16 sites in the U.S., which are part of the National Trends Network. This record shows that while the deposition is acidic, it has no significant upward or downward trend.

- NOAA has several monitoring sites worldwide located in remote areas. These data have established the natural acidity background. The higher acidity in industrialized areas are now recognized as perturbations of varying degrees of that natural background.

- Methods have been developed to measure the component of acidity that is deposited dry. This was a particularly challenging experimental task. Several sites are recording dry deposition rates. The data show that often half of the deposition is dry, rather than wet.

- NOAA has also served as a central point for standardizing instruments and methods between agencies, universities, and nations. A recent study, for example, has demonstrated unequivocally that the standard method that has been used for measuring a key nitrogen compound can produce erroneous (factor of two) results and hence must be replaced in many studies by other methods.

As noted by the examples in the three areas given above, the NOAA research emphasis has been on the discovery and characterization of the fundamental atmospheric processes and properties that influence oxidant and acids in the atmosphere. This approach not only provides the necessary improved understanding needed to make some assessments of the costs and benefits of acid deposition abatement, but it also contributes to the now-recognized need to understand the planet's atmosphere/surface as a system. This broader view is becoming more and more essential as science and policy are being required to jointly look beyond the regional problems like acid rain and recognize and address the global phenomena/issues of ozone alteration and greenhouse warming.

QUESTION 9:

The private research community is interested in access to NOAA's raw meteorological data, but is concerned that access may be limited to tailored data.

-- Do NOAA's current plans for a data access system allow outside access to raw data?

ANSWER: NOAA is currently planning for the development of a near real-time distribution of raw meteorological data on future NOAA transmission systems, most notably the National Weather Service's Advanced Weather Interactive Processing System (AWIPS-90)/NOAAPORT data distribution system. NOAAPORT, if implemented, would transmit raw meteorological observations such as National Weather Service surface and upper air observations, buoy, and ship reports. It must be noted that this list of "raw" data sources would continue to be refined as new or existing user requirements are being defined.

QUESTION 10:

NOAA has a responsibility under Public Law 95-95 (Clean Air Act Amendments of 1977) to monitor the state of the stratosphere on a long term basis. One of the principal instruments presently used in carrying out this responsibility is the ozone-monitoring SBUV device on the NOAA polar satellites.

-- What are your plans for continuing the SBUV on polar orbiters in the future?

ANSWER: Currently, the National Environmental Satellite, Data, and Information Service (NESDIS) is using the Solar Backscatter Ultra-Violet Radiometer, Version 2 (SBUV/2) to monitor the stratospheric ozone content. Four of these instruments have been purchased from Ball Aerospace Corporation. These instruments will provide coverage through the NOAA K,L,M era. (NOAA K,L,M, represents the next improvement to the NOAA polar orbiting system and is scheduled for operations from 1992 through 1995). As for monitoring the Earth's atmospheric ozone beyond the 1995 timeframe, plans are being made to continue to fly the Global Ozone Monitoring Radiometer (GOMR).

QUESTION 11:

In the next few years a number of new satellites will come on line, generating millions of environmental observations.

- Have you considered what increases in the ground observation system will be required to calibrate this satellite data? What will be the funding requirements?

- How will these observations be incorporated into the existing oceanographic observing program?

- What changes or improvements will be required in NOAA data management systems to store, access, and analyze the data?

ANSWER: - Yes. NOAA has been assessing the cost effectiveness of increasing ground observations for calibrating the increased satellite data in the program areas. The first is the real-time forecast services: weather, cryospheric (ice), sea level and ozone distribution. Generally, more ground observations are being planned by expanding present systems and/or upgrading their technology. An example is the conversion of the manual aviation weather observation network to the Automated Surface Observation System, which will provide more observations on a near-continuous basis. The greatly increased density of such a data set will facilitate improvement of the calibration of corresponding satellite data sets. The second program area is research, specifically in global change activities. Environmental monitoring systems are expected to provide new in situ data for calibrating satellite observations. These will then be archived in a manner that facilitates assimilation into numerical models. These will be used to improve the specific parameter fields generated by the models (e.g., sea surface temperature). Additional and improved tide gages will be placed by DOD on Pacific islands for use in calibrating satellite altimetry. Doppler radar systems will be placed at remote island sites by the Department of Defense to provide additional calibration data for satellite derived wind fields. The expanded volunteer observation ship program coupled with additional enhanced drifting buoys will improve sea surface temperature observations derived from satellite data.

The Administration is currently reviewing alternative data management improvements to cost effectively calibrate, store, and disseminate the projected increases in environmental data.

- Oceanographic parameters will be derived from the satellite data on an operational, routine basis and provided to NOAA (NOS, NWS), DOD, and other Government and commercial activities which require them. In addition, the data and derived oceanographic parameters will be added to the NESDIS data base so as to be available to retrospective users. In most cases, new or additional ground observations will be sent via satellite link, digitized, and made available to users through a commercial network or a broadcast system such as being considered under NOAAPORT.

- Changes necessary to store, access, and analyze these data include instituting a process of data management planning to determine requirements for ingesting, quality controlling, cataloging and analysis of these data; upgrading the data management system to be able to cope with the volume and complexity of the data to be processed, stored, and cataloged; taking maximum advantage of the most advanced yet operationally reliable storage and processing technology; and improving the accessibility of the data by developing an on-line data catalog and request system offering "one-stop" access to the entire NOAA data base. NOAA has recently instituted inter-agency efforts to address data management issues.

QUESTION 12:

NOAA's National Climatic Data Center has thousands of paper records, many of which are extremely valuable scientifically. Does NOAA have a program to microfilm such valuable data records that would otherwise be in danger of being lost because of deteriorating paper? Is there a program to digitize a small subset of these that are most useful to calculations?

ANSWER: Currently, the National Climatic Data Center (NCDC) microfilms primary manuscript records as they are received. In 1983, a five-year Government contract project was completed which placed

42 million pages of historical climate observations on microfilm. Subsets of the climatological records are digitized on a routine basis each month as the observations are received. Most of NCDC's digital records are for observations taken since 1948.

QUESTION 13:

Recently, scientists identified a mysterious hole in the ozone layer over the Antarctic. I understand that there is some disagreement over the cause of the hole and its global environmental implications. The appearance of the hole has been variously attributed to natural climatic fluctuations or human-induced changes. The most popular theory appears to be that the hole is a result of ozone destruction by man-made chlorofluorocarbons (CFCs) released from aerosols and refrigerants.

QUESTION 13.a.:

What research is currently being undertaken by NOAA and other federal agencies to study this phenomenon? How are these efforts coordinated? What are NOAA's findings on the cause of the ozone hole and the seriousness of this situation? When do you anticipate having definitive results?

ANSWER: Research Efforts to Date - The announcement of the discovery of the seasonal decreases in ozone over Halley Bay station by the British Antarctic Survey in May 1985 was completely unexpected and intriguing to scientists at NOAA and elsewhere. Re-examination of NASA satellite data confirmed the decreases not only at Halley Bay but over a large portion of the Antarctic continent.

NOAA researchers responded to this puzzle with new theoretical and experimental studies. Shortly after the discovery of the ozone hole, NOAA scientists sought to explain this dramatic phenomenon in terms of two separate theories: natural climate change and man-made chemical perturbation, both theories recognizing certain unique features of the Antarctic region, such as atmospheric circulation patterns, extremely low temperatures, and polar stratospheric clouds. The paucity of chemical data at the time for the Antarctic meant that it was difficult to decide which of these two theories, or a separate solar-cycle theory, was closer to the truth. Therefore, in the summer of 1986, NOAA joined with the National Science Foundation (NSF), the National Aeronautical and Space Administration (NASA), and the Chemical Manufacturers Association (CMA) to rectify this data-short situation by helping organize, support, and participate in the National Ozone Expedition (NOZE). A NOAA scientist served as the team leader, and she and her colleagues helped make up a 20-investigator team that greatly added to the chemical information regarding the occurrence of the "ozone hole." The team included investigators from the NASA Jet Propulsion Laboratory, the State University of New York, Stony Brook, the University of Wyoming, and the NOAA Aeronomy Laboratory.

Coordination of Research Efforts - Planning for NOZE '86 was coordinated by the National Science Foundation's Division of Polar Programs and the NOZE science team led by a NOAA scientist. Overall coordination of the Federal research effort in stratospheric ozone is done through the Federal Coordinating Council for Science, Engineering and Technology's Subcommittee on Atmospheric Research and the Interagency Committee on Stratospheric Ozone Protection. Finally, the atmospheric science community working in this area is an extremely well-coordinated one due to the high level of communication and collaboration among scientists at various institutions.

Findings from NOZE by NOAA Investigators and Others - The ozone hole is a strongly seasonal phenomenon. The NOZE expedition did a great deal to clarify the understanding of its seasonal nature. The expedition arrived in Antarctica in late August to find total ozone levels and vertical profiles that were rather normal for that latitude and time of year. In the next several weeks, they witnessed about a 35% decrease of the total ozone overhead. Standard theoretical atmospheric models and historical data suggest that, prior to 1975, the ozone had remained rather constant during this time of year. Therefore, in addition to the strong evidence provided by the historical data extending back to the 1960's and 1950's showing a downward trend in Antarctic ozone in recent years, the behavior observed in a single spring season showed the growth of the hole very clearly. Observations were made of the ozone abundance with two independent ground-based techniques, as well as from balloons. The excellent agreement of these data and the different principles involved in each apparatus confirm that the change cannot be due to instrumental artifacts (such as volcanic or other natural contaminants).

Other chemical species were observed besides ozone. Nitrogen dioxide was measured with two independent techniques. The observed abundances of nitrogen dioxide were only about one-third as large as Arctic observations or those predicted by "standard" global atmospheric theoretical models. They also did not change with time of day as would be expected and as has been observed at other latitudes. These observations demonstrate that the photochemistry of the Antarctic stratosphere is anomalous, but does not prove that the anomalies are related to the ozone loss.

Chlorine oxide is closely tied to the possible depletion of Antarctic ozone due to halocarbons. An upper limit of about 1 ppb of chlorine oxide was established near 20 km. This places important constraints on halocarbon theories of the ozone hole. A related molecule is chlorine dioxide. This molecule was measured and found to be present at extremely high levels. The observed amount of chlorine dioxide was about 20-50 times greater than that occurring elsewhere or predicted by the "standard" global models, clearly demonstrating that the chlorine chemistry in the Antarctic stratosphere is also perturbed. Other data from the 1986 measurements are still being analyzed.

Several theoretical studies, including the ones by NOAA and others, have considered what modifications to "standard" models might produce the "ozone hole" through chlorine and bromine chemistry. Such theories suggest substantial changes in both nitrogen and chlorine species in Antarctica. These theories involve speculative modifications to chemistry possibly due to polar stratospheric clouds, which are nearly unique to the Antarctic. Temperatures in other regions are only very rarely low enough to produce stratospheric clouds. Theory and observations show that the Antarctic stratosphere is characterized by widespread clouds during winter and early spring. Thus, if chlorine and bromine compounds are the cause of the "ozone hole," it is likely to be due to unique chemistry that may occur only at very cold temperatures, which would explain the confinement of the "ozone hole" to Antarctica.

The observed chlorine and nitrogen perturbations are roughly consistent with the theory that the ozone hole is due to CFC's. However, the uncertainties in the abundance of other chlorine and bromine species and in the chemical reactions that link the observed chlorine species to ozone depletions preclude, at present, from treating the observations as proof of the CFC chemical theory. The low nitrogen abundance does make the solar-cycle theory more difficult to accept. The long-term record of meteorological variables continues to suggest a role of dynamical processes in the ozone hole. Thus, while the role of CFC's seems now somewhat more likely and that of the solar cycle seems less likely, the detailed cause of the ozone hole has not yet been established with certainty.

NOAA Future Research

The fact that the chlorine chemistry in the Antarctic stratosphere is now known to be highly perturbed and the continuing need to define the dynamical processes make it mandatory to understand their roles in the ozone hole in much more detail. Hence, NOAA plans a greatly expanded effort during 1987. First, the agency's scientists will take an improved instrument back to NSF's McMurdo Base as part of NOZE '87. Others will provide year-round ozonesonde balloon launches from the South Pole during 1987. In addition, NOAA will join NASA, NSF, CMA, and university investigators in an aircraft expedition to probe the chemistry and dynamics at the stratospheric altitudes where the ozone loss is occurring. NOAA scientists will have five chemical instruments on board NASA's ER-2 and DC-3 aircraft, and one of these investigators will serve as mission scientist. NOAA investigators will serve as the mission scientist for both the NOZE '87 and the airborne expeditions. Analysis of the data from this year's expeditions should provide more definitive results regarding the nature and causes of the Antarctic ozone hole. Both teams plan to prepare a summary of their preliminary findings before they return to the U.S. Hence, these scientific statements will provide, in early fall, a current picture of the causes of the phenomenon.

QUESTION 13.b.:

With NOAA's budget requesting a decrease in atmospheric research funds, what effects will the cutback have on this research? What other research will be cut back?

ANSWER: The requested decrease in atmospheric research funds would not affect NOAA's global atmospheric research chemistry work. The following atmospheric research programs would be reduced: Program for Regional Observing and Forecasting Services (PROFS) (-$2.0M), severe weather research on mesoscale convective systems (-$1.25M), Federal/State weather modification grants (-$2.15M), and the Mid-America Research Institute supercomputer grant (-$3.0M since the grant was intended only as one-time funding).

QUESTION 13.c.:

Is the Antarctic hole associated with widespread global ozone reduction in the upper atmosphere? What are the possible climatic and health consequences of such a reduction?

ANSWER: As discussed in answer to Question 13b, the cause of the Antarctic ozone loss is not yet established. Until it is, the implications to global ozone depletion cannot be addressed meaningfully.

The climatic effects of global ozone depletion are thought to be related mainly to the non-uniform upper stratospheric cooling which would result from upper stratospheric ozone losses. Radiation theory suggests that a 25% drop in ozone would yield a 5° drop in temperature. Temperature changes, particularly if they are not uniform spatially, would mean changes in atmospheric circulation. However, atmospheric temperature, chemistry, and circulation are interrelated and the coupled calculations are still a research problem, and, as a result the consequences of this potential stratospheric cooling to climate on the Earth's surface (e.g., rainfall and temperature patterns) are not yet known. This is a major NOAA research focus.

Although health effects are not a NOAA research area, they have been studied by others. Their results are summarized as follows. Global ozone reduction would allow increased levels of ultraviolet radiation to reach the Earth's surface. The effects of such an increase were recently summarized by the Environmental Protection Agency in An Assessment of the Risks of Stratospheric Modification. That report finds possible health effects to be increased incidence of skin cancer and cataracts and suppression of the human immune system. Environmental effects are thought to include damage to agricultural crops, marine and terrestrial ecosystems, and increased incidence of urban smog problems.

QUESTION 13.d.:

I understand that not only the amount of ozone in the atmosphere but its distribution affect our climate. How is ozone distribution changed by human activity? What programs monitor those changes? How can we find out what effects those changes will have?

ANSWER: Current two-dimensional (height and latitude) models predict that the anthropogenic emission of chlorine- and bromine-containing chemicals would cause a depletion in upper stratospheric ozone and an increase in lower stratospheric ozone, thus changing the vertical distribution. In addition, high latitude regions are predicted to experience greater ozone losses than lower latitude regions.

A global ozone monitoriung network has been established to detect such changes. A ground-based network of about 75 Dobson spectrophotometers, coordinated by the World Meteorological Organization, measures total ozone, and has yielded a 26-year record. NOAA operates about 10 Dobson units that contribute to this network. Some of these Dobson units are capable of estimating the vertical distribution of ozone via the Umkehr method. In addition, balloon-borne ozonesondes give vertical profiles at selected sites.

Global monitoring by satellites will be available once testing of the NOAA Solar Backscatter Ultraviolet (SBUV) instrument is complete. This instrument is an operational, lower spatial resolution version of the research SBUV instrument flown in the NASA Nimbus Satellites.

Determining the effects of changes in ozone distribution on climate requires theoretical research using sophisticated models of the atmosphere. Such models would include chemistry, dynamics, and radiation and would be fully three-dimensional and high resolution representations of the Earth's atmosphere. Models of this sort are prohibitively expensive to run routinely on today's computers.

Preliminary results with present models using current computers indicate that upper stratospoheric cooling and lower atmospheric warming will occur if chlorine and bromine compounds continue to increase in the atmosphere. The former may possibly alter stratospheric circulation patterns and the latter is likely to add to the Earth's greenhouse effect. The lower atmospheric ozone increase and the direct greenhouse role of increasing CFC's abundance are thought to produce a surface warming that is a substantial fraction of that predicted for carbon dioxide. Clearly, these are potentially important atmospheric effects and hence deserve further study. NOAA laboratories are applying a major effort on understanding ozone and its atmospheric role.

QUESTION 14:

The news media and other private sources are increasingly using images taken by satellites. A prime example is the extensive use of satellite pictures from the Chernobyl accident. Some in the media have discussed the possibility of flying their own satellite (called Mediasat) to generate their own images. I understand that the Commerce Department, prompted by national security concerns, is developing regulations to restrict the private acquisition of satellite images, especially with respect to the resolution of the pictures to be acquired.

QUESTION 14 (a) and (b):

What is NOAA's view regarding the need to restrict the access to satellite images?

What is the status of the development of these regulations? What are the Commerce Department's current thoughts as to the restrictions that will be proposed?

ANSWER: NOAA agrees with the Land Remote Sensing Commercialization Act of 1984 that it is in the national interest of the United States for these data to be available on an open, nondiscriminatory basis.

The Final Regulations for Licensing Private Remote Sensing Space Systems were published in the Federal Register on July 10, 1987. These regulations were not "prompted" by national security concerns and do not restrict access to satellite images in any way. They simply set forth the procedural requirements for obtaining a license as set forth in Title IV of the Land Remote Sensing Commercialization Act of 1984, which can be denied on national security grounds.

QUESTION 14 (c):

How can the United States restrict the acquisition of images if they are generated by foreign sources, like the French SPOT satellite, which has the best resolution for commercially-available images? If restrictions are placed on U.S. companies and other foreign countries do not likewise develop such restrictions, won't U.S. companies be at a competitive disadvantage?

ANSWER: These regulations only apply to U.S. citizens or persons subject to the control or jurisdiction of the United States. Under Title IV, a license may be conditioned or denied because of national security or foreign policy concerns of the United States. The Departments of Defense and State, respectively, are responsible for making these determinations.

The final regulations accept the position of the Departments of Defense and State that this rapidly advancing technology requires national security and foreign policy concerns to be resolved on a case-by-case basis. This position reflects the fact that activities of foreign competitors at the time of license application must be considered. NOAA is committed to the commercial use of remote sensing to the maximum extent possible while still protecting vital national security interests.

QUESTION 14 (d):

Are there any First Amendment questions regarding the restriction of the public to this type of information?

ANSWER: Although one of the most important objectives of the Land Remote Sensing Commercialization Act of 1984 and of these regulations is to assure open, nondiscriminatory access to these data, it is possible that some restrictions may be imposed on operators for national security and foreign policy reasons. The Departments of Defense and State are responsible for making determinations for such national security and foreign policy concerns. During the rulemaking process, the press expressed concern that these criteria are so broad that access might be unreasonably restricted. They commented that the regulations should define the terms more narrowly and be more explicit in recognizing that any restrictions must comply with the First Amendment. The final regulations specifically affirm that these decisions are subject to First Amendment safeguards and that NOAA will comply with the First Amendment. However, the regulations also accept the position of the Departments of Defense and State that national security and foreign policy concerns for this new and rapidly changing technology must be resolved on a case-by-case basis.

Additional Questions Submitted by Senator Pressler

QUESTION 1:

What progress has been made over the past year in implementing the National Satellite Land Remote Sensing Data Archive?

ANSWER: Over the past year, NOAA has accomplished the following:

(1) Signed an agreement in May 1986 with the U.S. Geological Survey to jointly plan and implement this Archive at the EROS Data Center;

(2) Co-sponsored, with USGS, a workshop in September 1986 for Federal agencies on defining the basic data set for the Archive;

(3) Contracted with the Earth Satellite Corporation in September 1986 for an independent assessment of Archive requirements and architecture which included a public meeting with non-Federal data users and producers in February 1987 (final report due July 15, 1987);

(4) Signed an agreement in August 1986 with SPOT Image Corp. (USA) to supply SPOT 1 and 2 data to the Archive for a reduced non-commercial price (Archive price of $600 per CCT vs. the commercial price of $1475 per CCT).

Future funding for this program will be reviewed within the context of the FY 1989 budget.

QUESTION 2:

Has a definition of the Archive basic data set been developed per your letter to me dated December 30, 1986 (attached)? If not, could you give this committee an idea when such a definition will be established? If so, what are its major components?

ANSWER: In August 1986 after the agreement establishing the Archive was signed, NOAA and USGS formed an ad hoc Archive Study Group composed of members from both agencies to host the workshop for Federal agencies and prepare the preliminary definition of the basic data set for the Archive. By mutual agreement, work on this task and on the implementation plan for the Archive has been suspended temporarily, pending completion of the final report by Earth Satellite Corporation due July 15, 1987. We expect to complete a first draft of the basic data set definition by the end of the year.

QUESTION 3:

Has the Earth Satellite Corporation study related to the basic data set and Archive been completed? If so, summarize the conclusions and recommendations of that study.

ANSWER: The final report for this study is due very soon. Only preliminary results of the Earth Satellite Corporation (EarthSat) study are available and were presented in May 1987 at the Pecora XI Symposium in Sioux Falls, South Dakota.

QUESTION 4:

What are the current status and plans for funding the National Satellite Land Remote Sensing Data Archive and for procurement of data for the Archive?

ANSWER: Plans are currently under review within the Administration.

QUESTION 5:

What coordination with the U.S. Geological Survey is planned for developing and implementing a long-term strategy for funding the National Satellite Land Remote Sensing Data Archive? Your December 30 letter does not provide any insight into NOAA's long-range plans for the Archive mandated in P.L. 98-365. Could you outline for the record what you envision the role of the national archive to be through 1990?

ANSWER: NOAA has worked very closely with the USGS to establish this Archive. A plan for its continuation is currently under review within the Administration.

QUESTION 6:

What progress has been achieved during the past 6 to 12 months in development of the Cooperative NOAA/USGS Federal Land Remote Sensing Research Program?

ANSWER: NOAA and USGS signed the agreement establishing this cooperative research program at the EROS Data Center in May 1986. In September 1986, NOAA assigned a full-time research scientist to EDC to participate in this program. NOAA and USGS also recently completed a revised (near-final) program definition and implementation plan and are developing an affiliation agreement for participation in the cooperative research program by other Federal agencies. Discussions are underway for a soil scientist from the Soil Conservation Service of the Department of Agriculture to join the cooperative research program in the near future. Future program funding requirements will be reviewed within the context of the FY 1989 budget process.

QUESTION 7:

What are the current plans for funding the Research Program?

ANSWER: Decisions for funding the Cooperative NOAA/USGS Federal Land Remote Sensing Research Program will be made by each participating agency within the context of the FY 1989 budget.

ANSWERS TO QUESTIONS SUBMITTED BY
SENATOR JOHN KERRY
FROM
DR. D. JAMES BAKER

SENATE COMMERCE, SCIENCE, AND TRANSPORTATION COMMITTEE
HEARING MAY 19, 1987
ON NOAA ATMOSPHERIC/SATELLITE PROGRAMS

1. Your testimony discusses NOAA's research on global climate change. A comprehensive interagency research initiative has been proposed to increase our understanding of global environmental processes.

   * Which agencies should be involved in such an initiative? What is the appropriate role for NOAA?

   ANSWER: The principal agencies involved should be those with a major interest in earth sciences. These include NOAA, NSF, NASA, DOI, USDA, DOE, EPA, DOS, and certain elements, such as the Office of Naval Research, from the DOD. From the Executive Branch, both OSTP and OMB should be involved. The appropriate role for NOAA is development of prediction capabilities and to acquire, process, archive, and make available to the broad user community the long-term data that are required to monitor change in the climate system and to document and understand global environmental processes. This involves satellite measurements, direct measurements in the atmosphere, ocean and on land, and the support of research necessary to carry out such a measurement program.

   * You suggest that the funding cuts for NOAA's part of TOGA would have serious implications for the international program. Would restoration of funds to the FY 1987 levels provide adequate program support? How important are NOAA's TOGA-related activities in the context of the international program? What is the involvement of other federal agencies in the program?

   ANSWER: Restoration of funds to the FY 1987 levels would provide the program support necessary to continue the NOAA contribution to TOGA at its appropriate level. NOAA's TOGA-related activities are essential to the international program; it is the only U.S. agency providing operational data on a global scale in both the atmosphere and the ocean. NOAA's atmospheric and oceanic data, together with its modelling of processes that cause El Ninos, are a major factor in helping us understand this important phenomena. Other federal agencies involved include the National Science Foundation, the Department of Energy, and NASA.

* How would the other NOAA programs which you mention such as Radiatively Important Trace Species (RITS) and Geophysical Monitoring for Climate Change (GMCC) contribute to a global research initiative? Do you feel that these programs are adequately funded at the present time?

ANSWER: RITS and GMCC are critical elements of any program that is aimed at documenting global environmental change. Gases like CO2 are already changing our climate, and we must understand how fast such a change will occur, and what other processes in the ocean and on the land are involved. RITS will help us understand the effects of these gases, and GMCC documents the changes. These are first-priority items for support; yet neither of these programs has adequate support. To do what is needed, about twice the current level of funding would be appropriate.

* Can you make suggestions for related research which would fall within NOAA's expertise and contribute to our understanding of global climate change?

ANSWER: NOAA's research programs, which are carried out in support of its mission to document and understand environmental change, are an essential part of the nation's effort in this area. Examples of related research include the on-going research on El Nino-Southern Ocean processes and links with mid-latitude circulation, global climate modelling, research in understanding the physical, chemical and biological interactions of trace gases in the environment, research on the cause of droughts such as those in Africa and the U.S., and studies of heat transport in the ocean. Of equal importance to understanding global change is NOAA's support of CO2 measurements which has been a critical factor in our understanding of how man affects our environment. Another critical factor is the changing sea level.

This is a NOAA responsibility, yet NOAA has never had adequate funding to carry out a proper global sea level monitoring program. Global environmental change will manifest itself in many ways, but one of the most obvious will be an increase in sea level as CO2 causes the atmosphere and ocean to warm up. Since 75% of our population lives within 50 miles of the ocean, sea level is of vital concern to our national well-being.

2. You mention the importance of satellite observations to understanding the atmosphere. I understand that these satellites generate millions of observations.

* Do you feel that our current system of data management is adequate to make full use of the satellite data available? Could you offer any suggestions for improving data management?

ANSWER: Over the next decade the flow of data about the earth will increase from thousands of observations each day of some of the parameters like ocean winds and waves to many millions of observations per day. The digital data rates will be more than ten trillion bits per day. Proper handling of all these data at an affordable cost is the biggest technological challenge to be faced. Our current data management systems are not adequate to handle the massive data stream. However, the technology, involving supercomputers, optical disk storage, and new communications networks, that could handle the data is all available today. It simply needs to be put into place. The planning is well in hand, with NOAA and NASA taking the lead, and some pilot demonstration systems have been developed. What is lacking is recognition that we need operational systems and adequate funding to evaluate and implement these new systems into place.

* Have you found that data needed from NOAA was readily available in an easily used form?

ANSWER: Some of NOAA's data sets are currently available in easily used formats, and NOAA is operating some very successful joint data centers, particularly in oceanography. However, many data sets are not easily obtained. It has been particularly difficult to obtain operational satellite data, for example sea surface temperatures, in a format that researchers can readily use. As a consequence, some researchers have developed their own data systems. This is largely due to lack of funding of the NOAA data management program.

* Please describe how satellite observations are verified and calibrated. Do you feel that any changes are needed in this area?

ANSWER: Satellite observations are verified with measurements made directly in the atmosphere, for example with radiosondes, in the ocean, for example with current meters, and on the land with temperature and radiation measurements. Calibration is carried out with comparison techniques onboard the satellites themselves as well as with measurements over special comparison areas such as deserts like White Sands. The main need here is full support of such measurements, so that as we look to long-term measurements, we have confidence that what we see is really environmental change rather than just instrument drift. This is a program where NOAA, NASA, DOD and other agencies involved in satellites all must participate.

3. Please describe international research efforts in the area of global change.

ANSWER: There are a large number of such programs now in place or being planned. Examples of these include the International Geosphere-Biosphere Program, the World Ionosphere-Thermosphere Study, the Global Tropospheric Chemistry Program, the World Climate Research Program, the International Satellite Land Surface Climatology Project, the Greenland Ice Sheet Program, and the International Lithosphere Program. Details on these and others can be found in various reports of the National Research Council.

* What is the U.S. contribution to such an international program?

ANSWER: The U.S. tends to set the pace for international programs because of its large scientific community, its leadership in science and technology, and its financial support of major programs. Yet without international participation, the problems, with their broad scope, will never be addressed properly. As a consequence we have a special responsibility not only to provide technology and personnel, but also to assure long-term continuity and stability.

* How can NOAA contribute?

ANSWER: NOAA has the responsibility for conducting a program to obtain, maintain, and make accessible the long-term data necessary for us to understand global change. Each of its elements contribute to this responsibility. It can contribute only if there is recognition that such data is indispensible, and that NOAA will have the support to carry out this responsibility.